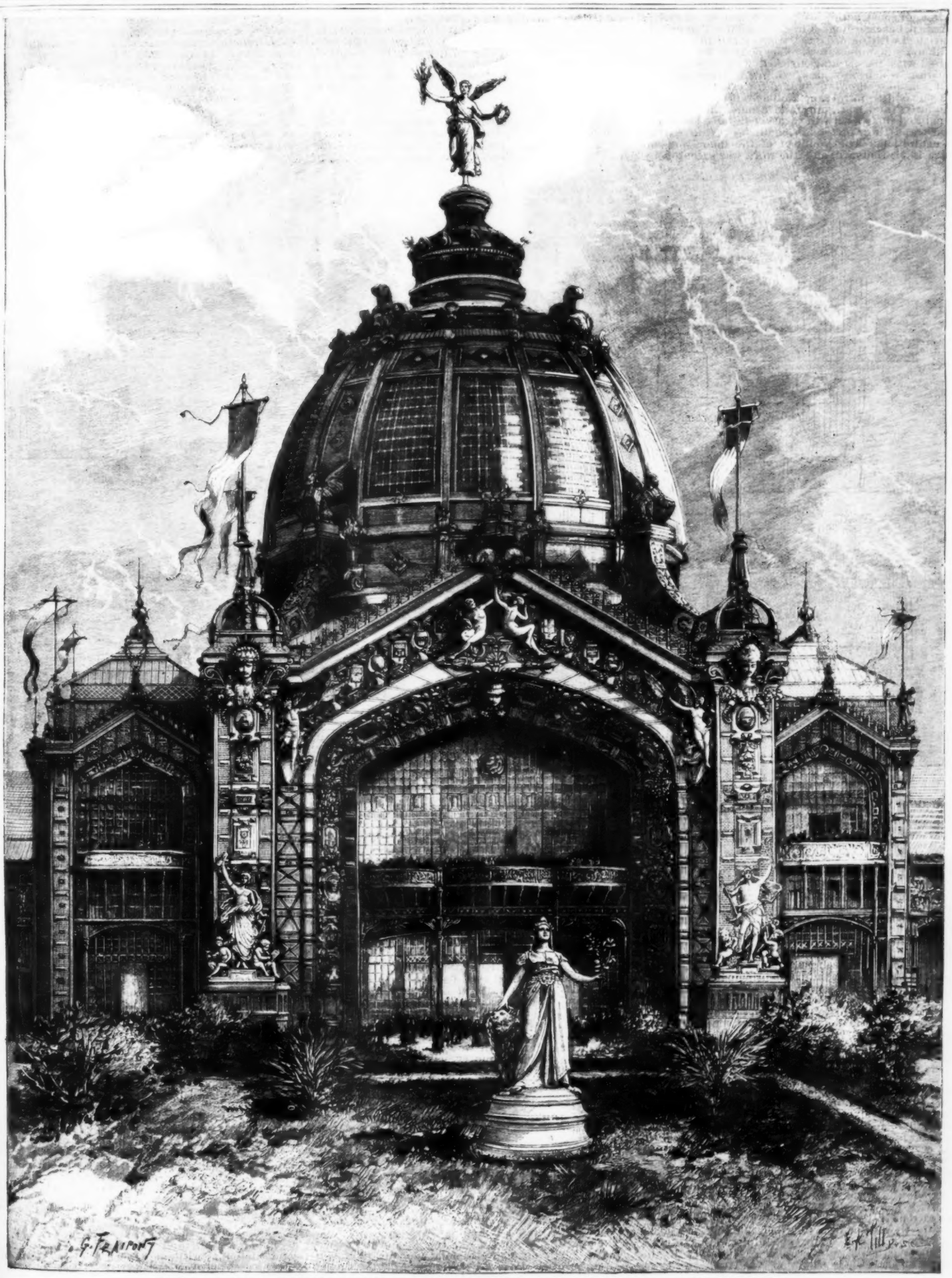
SCIENTIFIC AMERICAN

SUPPLEMENT, No. 701

Scientific American Supplement, Vol. XXVII., No. 701
Scientific American, established 1845.

NEW YORK, JUNE 8, 1889.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



THE PARIS EXHIBITION—THE CENTRAL ENTRANCE AND DOME.

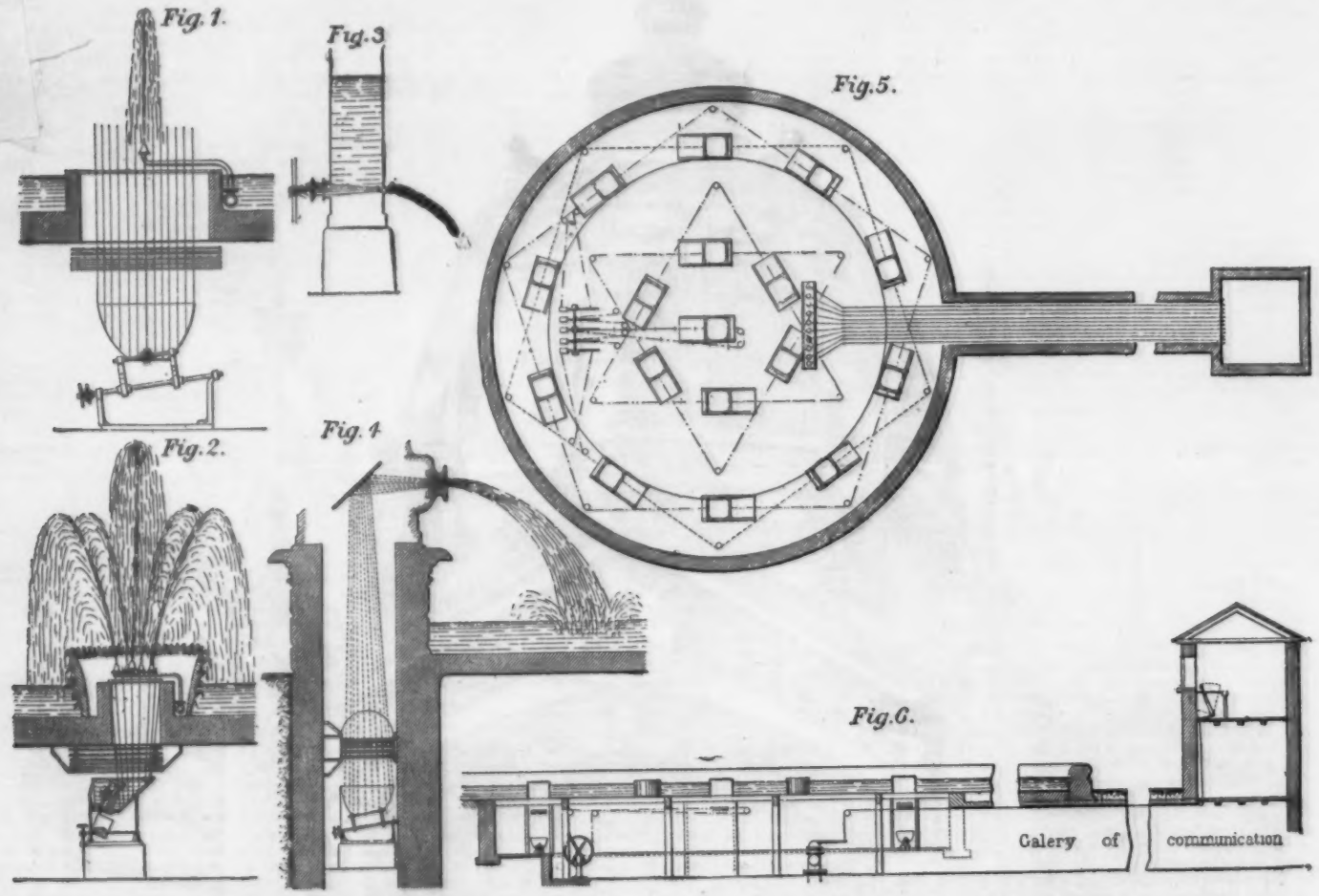
THE PARIS EXHIBITION—THE CENTRAL ENTRANCE AND DOME.

FACING the central garden is the principal entrance to the Exhibition, of which we give an engraving from *L'Illustration* and the following particulars from *Engineering*. This portal, which is beneath the dome, 200 feet in height and 98 feet in diameter, is situated exactly in the axis of the Champ de Mars, and therefore immediately opposite the Eiffel tower and the Trocadero. To the right and left of the dome are pavilions which are built in two stories. On the ground floor these give direct entrance to the Miscellaneous Industries Court, while the first floor is occupied by large salons. Access to the first floor is gained by means of four staircases, which also communicate with a gallery 33 feet above the ground, running around the dome, and in front widened out into a balcony, from which a view of the central gardens is obtained. While the lines of construction are preserved, the ironwork is concealed beneath a mass of decoration. The cupola is enriched with stained glass, which forms the exhibits of different manufacturers. The body of the dome is painted with panels and enriched with tapestry and draperies, which are also exhibits. Porcelain and other ceramics enter largely into the decorations. On each side of the portal are monumental figures typical of industry and commerce, and around the entrance are painted shields with the arms of different towns in France and those of foreign countries taking part in the exhibition. The architect of the dome and entrance is M. Bouvard, and the work was executed by M. Moisant. The work of erecting a dome of such proportions and in so short a time as was at the disposal of the contractor was one of no small magnitude. The dome is supported upon eight great columns 131 feet high, arranged in a circle 98 feet in diameter, and connected together at different heights by circular girders. The dome itself is framed of eight half principals and eight intermediate half principals; these latter rest upon a curb secured to the top of the circle of columns. The eight main principals are practically a curved continuation of the columns themselves. All the framing of the dome meets near the center in a ring, which also serves as the base of the crowning decoration, an allegorical group of figures over thirty feet in height. The construction of the side pavilions calls for no special mention here; the total amount of ironwork in these and the central dome is 867 tons. The method of erecting this great work was extremely interesting. The main scaffolding employed consisted of an annular sixteen-sided polygon, about 150 feet high and 13 feet deep, the diameter being such that the outer face of the staging lay just within the standards carrying the dome. The scaffolding was divided into eight stories, connected by stairways. The top of the stage was boarded over its whole width and protected by inner and outer handrails; this top platform was made wider than the main body of the stage, and was carried on corbels. As the whole of this structure was extremely light, it was necessary not only to reduce the weights of ironwork to be lifted, but also to avoid throwing any great strain upon the staging. A crane was employed for raising the ironwork, the weight of each piece of which was limited to three tons.

THE PARIS EXHIBITION—THE ILLUMINATED FOUNTAINS.

THE illumination by night of the fountains and cascades of the Exhibition grounds has been carefully planned, chiefly with a view to general impression to be produced by the entire system upon the spectator, and that the luminous lines shall harmonize artistically with the lines of the adjacent buildings. The central fountain of the park, designed by M. Coutan, represents France lighting the world by her torch, and surrounded by Science, Industry, Agriculture, and Art. As to the lighting of the aqueous devices, the *Engineer* says, below each basin are circular subterranean chambers, Fig. 6, solidly constructed in Coignet cement; their roofs are pierced with holes, Figs. 1, 2, and 4, closed with plate glass at the starting point of jets of water, so that the light when it once gets inside these jets follows their curves, because by the laws of internal reflection it cannot escape. The principle is that long since used in Dubosco's luminous fountain, and the effects produced are infinitely more beautiful than those evolved by the cheap method of throwing colored lights from a distance through the air upon water devices. M. J. Charton states that in each chamber an arc lamp of great intensity is fixed, Fig. 3, from which all the light is thrown out horizontally by means of a parabolic mirror; the beam is received by a mirror placed at an angle of 45 degrees and is thereby thrown upward, and after traversing changeable colored glass; also the glass at the base of the water jet colors the latter red, green, blue, or some other hue, as the operator beneath the fountain changes his stained glasses. Each arc lamp used in the illuminations just described will yield the light of from 500 to 1,000 carcel standard lamps. In order to illuminate parabolic jets, which escape from horns of plenty, it is necessary to arrange several mirrors in such a way that the light shall follow the trajectory of the water. In this case the water passes between two concentric tubes, and into the smaller of these tubes the beam of light is projected. Luminous fountains have already been exhibited in London, Glasgow, and Barcelona; but these of the Paris Exhibition, installed under the direction of M. Bechmann, chief engineer of the service for supplying Paris with water, and by Messrs. Galloway & Co., of this country, will be of exceptional importance, because of the great masses of water in movement, the intensity of the light employed, and improved methods introduced. The great fountain under the Eiffel tower, erected and sculptured by M. De Saint Vidal, will be illuminated by means of four arc lights, each of 350 carcel lamp power. All this lighting of the Champ de Mars will be effected from three groups of central stations, presenting complete demonstrations of several systems of distributing electrical force. The first will be in the isolated garden alongside the Avenue de la Bourdonnais, between the machine gallery and the building containing miscellaneous exhibits. the second on the bank of the Seine near the bridge of Jena, and the third along the Avenue of La Bourdonnais, near the Press Pavilion.

The projected method of lighting produces gorgeous effects. Might not the plan long ago tried at Nice be reproduced at the Paris Exhibition, of having an aquarium with the tanks disposed all around its walls, and everything arranged so that little or no light can enter the room except that reflected in flashes from the glittering sides of the specially selected living fish? The effect is said to have been fine.



THE PARIS EXHIBITION—THE ILLUMINATED FOUNTAINS.

THE STRIPPING OF FILMS FROM GELATINE NEGATIVES FOR PHOTO-MECHANICAL PROCESSES.

THE stripping of a negative film when it is in collodion is a comparatively easy matter, but, in the present state of photography, it is quite necessary for one who takes up certain photo-mechanical processes to have a ready means of stripping gelatine films. The descriptions that we have of such processes are, so far as I know, meager. Wilkinson, for example, in his excellent little book on photo-engraving and photo-lithography, describes methods of stripping collodion negatives only. Such descriptions as I have seen are not generally wrong in principle, they are merely insufficient in detail. Any one taking them up and trying to work from them will find that he is not at once able to strip negatives and get satisfactory films from them, but that he has to work out all the details himself.

The process generally advocated is that of Plener, in which hydrofluoric acid is used to separate the film from the glass. Plener's method is so ingenious that one is sorry to pour any cold water on it, but apart from the use of hydrofluoric acid, which every one will avoid who possibly can, it would appear that the etching action of the acid on the glass has nothing to do with the stripping, inasmuch as almost any other acid will act as well as hydrofluoric acid.

This is not an observation made originally by myself, but was, if my memory does not fail me, made by Mr. W. B. Bolton some six months ago. The action, whatever it is, is really the same as the "frilling" of the plate. Although almost any acid that is strong enough or that has a strong enough action on gelatine will serve to strip, it is, perhaps, scarcely correct to say that any other acid will do as well as hydrofluoric acid, inasmuch as I have found differences in the certainty in the action of different acids. After many experiments, I have adopted sulphuric acid as the most certain in its action of any acid, hydrofluoric acid included.

The difficulties that will generally be found in stripping are as follows: (1.) The films refuse to strip at all. A process which will be quite successful with a negative freshly developed and fixed will often be found not to work at all with a negative that has been treated with alum, and is, say, a year old. (2.) The stripping takes place between the new support and the film, instead of between the film and the glass. (3.) The film after stripping stretches so that not only is the negative to a larger scale than before—and with a corresponding increase of density—but probably there is likewise distortion, as it is highly improbable that a film will stretch exactly to the same extent in all directions. I saw a complaint of this stretching in one of the photographic journals only a few weeks ago. (4.) The film is so hard and brittle when dry that it cannot be handled without danger of cracking it. And (5.) The film twists or curls in drying, so that it is impossible to get perfect contact between it and a flat

surface, such as a collotpye film. It has taken me more trouble to insure getting the film in a perfectly flat and flexible form than has anything else.

If the following directions be precisely carried out, it will be found that any negative, however old, may be stripped with certainty and without encountering any of the difficulties just enumerated. It need scarcely be mentioned that, if the negative has been varnished, the varnish must first be removed by the application of hot methylated spirits.

The following is made up:

Hard gelatine.....	2 ounces.
Water...	10 "

The gelatine is, of course, soaked in the water till it is soft, when heat is applied. I can recommend Coignet's "Gold Label" gelatine. The solution should be heated to not very far short of the boiling point, and should then be filtered through flannel.

A negative to be stripped is warmed,* accurately leveled, and a certain amount of the gelatine solution is poured on the surface, and is guided with a glass rod till it covers the surface evenly. It is of great importance to measure the quantity, as the ultimate thickness of the film depends on this, and it has to be borne in mind that printing has, if the film is to be used as a reversed negative, to go on through the gelatine.

A quantity of four ounces per square foot will be found suitable for average work. This gives a film, when dry, of about a hundredth part of an inch thick. This sounds very thin, but, in fact, it is a good stout film. The film of an average gelatine dry plate, when dry, is only about one two-thousandth part of an inch thick. Still, one-hundredth of an inch will not interfere with ordinary work. For very delicate work the amount of the gelatine solution may be reduced to two ounces per square foot. It is not advisable to use less than this, as otherwise the films will be too delicate for free handling. It is quite possible to flow as much as ten ounces per square foot on glass without any special arrangement for preventing it from overflowing the edges, but a film of the thickness so got is, in my opinion, far too thick for any practical use.

If, however, such a film be wanted for anything, it will be necessary to give four times as long in each solution as is hereinafter directed, as it takes a long time for any liquid to penetrate a very thick film.

A saturated solution of chrome alum is taken, and there is added to it, drop by drop, liquid ammonia, till there is the slightest possible permanent flocculent precipitate. This is merely to neutralize any free acid that there may be, as any such free acid greatly impairs the setting powers of the alum solution.

The gelatine solution having set on the plates, the latter are placed for five minutes in the chrome alum solution. They are then removed and are washed till all the blue color of the chrome alum has disappeared. They are then placed in a bath of methylated spirit for half an hour. They are taken from this, the surface is blotted with blotting paper, and they go into a bath of—

Sulphuric acid.....	1 ounce.
Water.....	2 pints.

I use ordinary commercial sulphuric acid. I do not know the exact specific gravity of it, nor is it of much importance, as a considerable variation in the strength of the bath is permissible.

The following solution is now needed:

Liquid ammonia.....	1 ounce.
Glycerine.....	1 "
Water.....	2 pints.

The films are left in the sulphuric acid bath till the greasiness caused by the alcohol disappears; this will take about half an hour. At the end of that time, it will be found that the corner of a film may be lifted, and that the whole will leave the glass with the greatest ease. The films go direct from the sulphuric acid bath to that of ammonia and glycerine. The object of the glycerine is to secure flexibility of the films, the object of the ammonia is to neutralize the sulphuric acid. It takes a long time to wash sulphuric acid out of a thick film, and if a long time be given in this case, the film will stretch. The small amount of sulphate of ammonia produced in the film by the acid and the ammonia is quite harmless.

Glass is prepared by rubbing the surface with a solution of a few grains of beeswax in each ounce of benzine, and by polishing this away with powdered talc. A film is taken from the last solution as soon as it tastes of acid, no longer, probably in about five minutes; it is placed on a piece of glass, a pad of blotting paper is placed on the back of it, and the squeegee is applied with great vigor. The plate supporting the film is then placed in a fairly warm place, so that the latter may dry; but I find it necessary, after a few hours have elapsed, to paste down the edges with narrow strips of paper and gum solution, otherwise they are sure to rise from the glass before the whole film is dry, and it will be found impossible to get flatness. An attempt must not be made to strip the film from the temporary glass support until it is perfectly dry. Then it is only necessary to insert the thin blade of a knife, when the film will come away in a form in which it is quite handleable, is beautifully flexible, and may be printed from either as a direct or a reversed negative.

It is to be observed that if the film, before it goes into the sulphuric acid, be dried spontaneously in place of by the aid of alcohol, the gelatine support will probably part from the film instead of the film parting from the glass.

The acid bath may, of course, be used for a long time; in fact, as long as it acts. The ammonia and glycerine bath may be used as long as it continues to smell distinctly of ammonia.

I tried drying the stripped films on vulcanite, but found it impossible to prevent them from leaving the surface before they were dry, with the effect that they were hopelessly far from flat.

I fear that the process as I have described it reads as if it were very complicated. It is not really so. A negative may easily be stripped and be drying within two hours of the time of beginning operations, and quite a number may be done at the same time. The drying is the thing that takes longest. With films of average thickness it takes twenty-four hours.

W. K. BURTON.

* I assume here that the negative is one that has been treated originally with alum. If it has not been, it is necessary before the stripping process is begun to treat the negative with alum and allow it to dry, otherwise the hot gelatine solution will probably have the effect of destroying the negative by melting the film. It is particularly necessary to observe this in the case of negatives that have been developed with ferrous oxalate.

ARMOR FOR SHIPS.

AT a recent meeting of the Institution of Civil Engineers, the paper read was on "Armor for Ships," by Sir Nathaniel Barnaby, K.C.B.

The author described and illustrated by drawings the applications of armor to ships in the French navy between 1858 and 1888. He directed attention to the increasing thickness of armor to meet the growth in the gun, to the corresponding reduction in the area of surface covered, and to the eventual disuse of side armor for protecting the batteries. Thereupon the development of quick-firing shell guns was rapidly extended, and high explosives, such as gun cotton, melinite, bellite, lyddite, etc., were introduced, and were being perfected as bursting charges for shells.

On the assumption that thin armor was, and would remain, effective against such projectiles, armor of 4 in. and 5 in. in thickness was again being demanded, by sailors, for the defense of the sides of the ship in front of the batteries. Believing that such armor would be costly, ineffective, and even dangerous, and that it would tend more than ever to reduce the number of ships which could be brought into action, the author drew attention at the outset to what he conceived to be a wrong policy for this country.

He observed it was certain that, apart altogether from these quick-firing guns, it would only be necessary to put up targets of thin armor and expose them to the fire of heavy projectiles in order to show the frightful wreck behind the target which occurred years ago, and which led to thicker and ever thicker armor. But there would be this difference in favor of the gun, that the projectiles were heavier and stronger, the velocities higher, and the explosives more powerful.

He showed that, without going beyond the ships now building, an expenditure of £1,000,000 per ship had been reached. On examining all such large ships, whether British or foreign, it would be discovered that they were most seriously exposed to the attack of the powerful weapons now in rapid course of development. The naval authorities had to decide whether they would concur in still further enlargement in individual ships, or would endeavor rather to meet these weapons by combining the forces of smaller ships.

The author considered there was no difficulty in taking the latter course, and that it had many advantages. The principle of subdivision was consistent with perfect seaworthiness, with speed as high as that of the largest ships, with the control of weapons which could be used with fatal effect upon the most powerful ships of the enemy, and with such powers of endurance as would enable the smaller vessels to receive injuries from the largest ships without necessarily fatal results.

If it should be said that this dispersion of force entailed a risk of destruction in detail, by encounters with units of greater force in the hands of an enemy, that argument simply went to show that an organizing skill would be required to insure the presence of the united forces where they were needed. Referring to the concentration of material value in a few ships, thus preventing the construction of many ships, he remarked that in the line-of-battle ship of fifty years ago the value of the material for a single command was about £100,000, and the value per man in the crews of such ships not more than £150.

In the ironclad of 12,000 tons of to-day, the value of ten of the former line-of-battle ships was intrusted to each captain, and not less than £2,000 to each man in the crew. In order to put forward in a concrete form his views as to the type of fighting ship most suitable for the present needs of the British navy, he had brought forward a design. It was for a ship of 8,200 tons displacement, costing one-fourth of the so-called first class battle ship of to-day. A sufficient number of ships of this type could probably be built and armed in two years. It might be said that nothing could be done upon such dimensions, and at such cost, to entitle the ship to be called a battle ship. But the seventy-four gun line-of-battle ship of fifty years ago had only a total displacement of 3,000 tons, and the eighty gun ship of the same period 3,500 tons.

This design came between the two, and would only cost as much as three seventy-four gun ships. If the British government determined to spend money upon invulnerable ships, the difficulty in getting enough ships would be perpetually growing. There was no obstacle, except in finding the money, to making an invulnerable ship. Ships could be built and navigated which no torpedo, or ram, or gun that could be worked from any ship now in existence could fatally wound. In such a ship every man might be absolutely protected, high explosives notwithstanding. But there would be so few of them that commerce and the colonies might be lost for want of ships, and there would only be the satisfaction that the sailors had been protected in such ships as existed.

The question was, Ought England at the present moment to move still farther onward in increasing the size and cost of heavily armored ships, requiring four or five years to complete? Or, ought this country rather to endeavor to increase rapidly the number of protected ships, capable, by reason of their speed and armament, of taking part in any engagement with an enemy, however powerful?

In this exposition of the uses of armor, it was apparent that fighting ships must continue to use it. When armor was employed in the form of comparatively thin horizontal plating, experiment seemed to have shown that steel, low in carbon, was the best material. When it was employed in the form of a wall, either upright or inclined, and comparatively thick, the value of a hard face became very marked.

The various modes of manufacturing thick armor for upright, or nearly upright, defenses were described, and illustrations were given of the comparative resisting power of compound and of forged steel plates; also of two armor plates of great excellence, manufactured at Sheffield, one of them compound, having a steel face and an iron back, and the other of forged steel throughout. The superiority of the compound plate was very marked.

The author also drew attention to the improvement effected by the use of the hydraulic press in manufacture of thick armor plates. To many minds it seemed that the hope of the future for peaceful sea traders lay rather in abating than in increasing the individual superiority of the special ship of war. No efforts should be spared to raise the character and strength of the fast mercantile ships. But it must be admitted that there was no prospect of a diminution in the use of armor in regular fighting ships.

The evident tendency was toward its introduction into every fighting ship. Referring to the aspect of the question from the side of the attack, the author remarked that when the large unarmored structures in the French ships were considered, the seriousness of the new attack became evident. And it was the artillerist who must be first impressed. It was of more consequence to be able to inflict damage in action than to be able to avoid it. The best defense was to be found in a vigorous attack.

It must be understood that the powerful ships in modern navies were not protected, so far as their batteries were concerned, by the armor which the French thought necessary. They were unarmored from their lower decks upward. The author asked, Was full advantage to be taken in the British navy of these high explosives in any war which might break out within the next two or three years? Writing before the government proposals had become known to him, he would agree cheerfully to any suggestions by the government, as to the size of the new ships, and as to the use of armor for them, if they were laid for approval before some competent technical committee for a month.

If the author were responsible for the steps which must be taken by the administration, he would insist upon having the soundest independent judgment which could be obtained. He felt satisfied that if such a body as the council of the Institution had been consulted in 1868, 1871, and 1875, when naval ordnance was in a crisis and under serious debate, it would not have happened that the question of breech loading would have been kept closed from 1866 until 1879. He believed that if such a body had been consulted in 1859, it would have appreciated better the significance of the four ironclad ships then building in France, and the government proposals would have been wisely modified.

The attitude of the engineer toward questions of war material differed from that of a member of a political administration, and from that of naval and military officers. The engineer was mainly interested in the question of the development of the powers of the weapons of war, and he was constantly thinking how they might be extended, and how the maximum of power might be got out of a given expenditure. The tendency with the administration was to estimate the comparative value of available resources of rival governments, and not to look beyond the immediate future.

It might be seen from the speech of Sir John Pakington, when introducing the navy estimates, on the

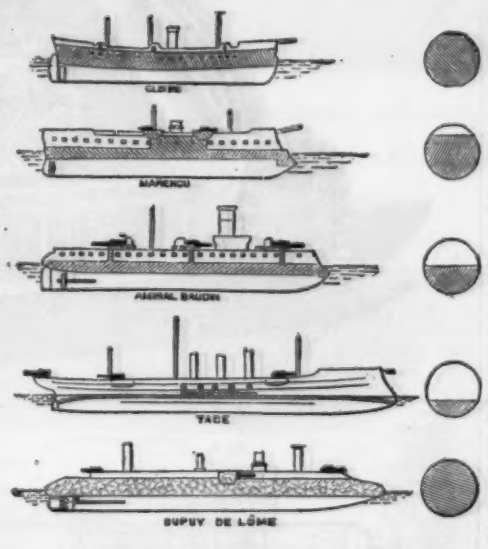


TABLE I.—PHASES OF ARMOUR.

1st *Period. Floating Batteries.* 1854-58.

2nd *Period.* 1858-1888.

Gloire.

1858. 1st phase	Armour (side) 4½ inches	5800 tons, speed 12½ knots	Percentage of weight devoted to armour, 15.

Marengo.

1869. 2nd phase	Armour (side) 7½ inches	7750 tons, speed 13½ knots	Percentage of weight devoted to armour, 17.

Baudin.

1880. 3rd phase	Armour (side, &c.) 22 inches	11,300 tons, speed 15 knots	Percentage of weight devoted to armour, 33.

Tage.

1886. 4th phase	Armour (deck) 3 inches	7050 tons, speed 19 knots	Percentage of weight devoted to armour, 14.

Dupuy de Lôme.

1888. 5th phase or return to 1st phase	Armour (side) 4 inches	6300 tons, speed 20 knots	Percentage of weight devoted to armour, 15.

25th of February, 1859, and when the French ironclad seagoing ships were being built, how easy it was to undervalue new forces. This administration undertook the building and conversion at that time of sixty-seven wooden line-of-battle ships and frigates; and they were all in the hands of the dockyard authorities, in various stages of production, a few months afterward. But not one of them was suitable for the circumstances of the time. Many of them were never finished.

WATER-TUBE BOILERS FOR WARSHIPS.*

By J. I. THORNYCROFT.

IN modern warships the weight to be carried is an ever increasing source of difficulty. The essence of a skillful design is the combination of great powers of offense and defense, of speed and coal endurance, in a limited displacement. In the ironclad of to-day, evidence may be seen in every part of the struggle of the designer to reduce the weight of his elements without impairing the efficiency of the structure as a whole. Forced to increase the thickness of his armor, he covers with it only a small portion of the hull, and he hardens the face of his plates to increase the resisting power of a given weight of material. The structure of the hull has been elaborated until the amount of material has been reduced to a minimum consistent with safety. The weight of the guns has been reduced, I am inclined to think, quite as much as is desirable when the amount of the charge is considered; and the engines, like the guns, have had their pressures and velocities increased until progress in these directions appears to have reached a limit.

In the boilers, however, there is still much room for reduction of weight, not only by economizing material, but also by economizing fuel. Mr. Sennett's paper, last year, shows how strong is the pressure brought to bear upon the engineering department with a view of saving weight in the boilers. His answer has been, reduced test pressures and reduced thickness of material. Economy of fuel in steam boilers depends greatly on the amount of heating surface that can be allowed for a given evaporation. If we can estimate the weight of a unit of heating surface in different classes of boilers, it becomes a very simple matter to calculate the comparative weight of the boilers for a given economy of fuel. On the other hand, for a given weight of boiler we can estimate the saving in fuel, or the increase of power, due to a change from one class to the other.

Some experiments were made at Portsmouth two years ago having a direct bearing on this subject. By an evaporative trial, at natural draught, of two boilers, the one locomotive, and the other water tube, the heating surfaces of which were in the ratio of 1 to 2·3, it was found that in the case of the latter boiler the rate of evaporation could be increased in the ratio of 1 to 2·36 with the same economy.

It follows that a water-tube boiler will evaporate a little more water per foot of surface than a locomotive when working equally economically, and, therefore, under these conditions, the weights of the two types will be proportioned to one another as the weights of a unit of heating surface. The weights of boiler and water and fittings per foot of heating surface of the locomotive and water-tube boilers tried at Portsmouth were 25·6 lb. and 9·61 lb. respectively. The weight, therefore, of a water-tube boiler and water, working at the same economical rate as a locomotive boiler and water, will be less than half.

In practice we prefer to make a smaller reduction in weight, and to work the boilers less hard by giving a larger allowance of heating surface for a given quantity of water to be evaporated. By this means better economy is obtained, and much less stress is put upon the boilers.

Whereas the common wind pressure for locomotive boilers in torpedo boats is from 4 in. to 5 in. of water, we do not usually exceed 1½ in. to 2 in. with the water tube, and a corresponding reduction could doubtless be made in warship practice. The following figures will show the amount of the saving in weight:

	Indicated horse power.
Indicated horse power per ton weight of water-tube boiler, including all fittings, mountings, water pipes, donkey, spare gear, and funnel	68
Locomotive boiler of same power in a torpedo boat	48
Locomotive boiler in latest English torpedo catcher	48
Boilers of H.M.S. Anson	21·3
" P. and O. steamers	16·6

This boiler has other qualities which render it particularly suitable for warships. In addition to the saving in fuel due to the greater economy, the power of getting up steam in a short interval of time must tend to further saving, for when it takes a long time to raise steam it must be kept up continuously, if there is a possibility that it may be wanted with only a notice of an hour or two. With the power to get up steam quickly, it would be sufficient to keep steam in one boiler, for the purpose of starting auxiliary engines and warming the main engines. It has been found that steam can be raised in from 15 to 20 minutes without risk of injury, and forced firing has never caused leakage of the tubes.

The water-tube boiler consists simply of three cylinders lying parallel to each other, the smaller being at the base of the structure, and the larger one at the top. (See Fig. 1 of engravings herewith). These cylinders are connected by means of two large tubes at the fire-door end, and are stayed at the opposite end by a triangle frame. A further connection exists between the top and bottom cylinders in a great multitude of small tubes. These are the steam generating tubes. On looking carefully, it will be noticed that the inner row of tubes, forming what would be the crown of the firebox, and the outer row, forming what would be the shell in an ordinary boiler, are, by means of a very simple alteration of their ends, made to lie quite close together, so that none of the products of combustion can pass between them (Fig. 3).

The lower part of the upper cylinder is thus protected from the direct action of the heat. The tubes are fixed in the cylinders by expanding in the ordinary way, and an outer casing of thin steel covers the whole. In the upper half of the upper cylinder a curved baffle plate with serrated edges is fixed to protect the steam pipe and effect the separation of the water and steam. The firebars are disposed at the base of the boiler, and between the two lower cylinders. They are surrounded by firebrick slabs, which act as protectors to the lower cylinders and as bridges over which the flame must pass on its way to the chimney.

When steam is required, the boiler is filled with water up to nearly the middle of the upper cylinder, and the fire is lighted. The products of combustion pass over the side bridges and through the spaces between the lower ends of the generating tubes, into the spaces between the tubes, and along them to the upper half of the upper cylinder, whence they pass to the funnel. In addition to the heat absorbed from the gases a great amount of radiated heat is received by the tubes forming the crown of the furnace.

The heat absorbed by the tubes is at first only communicated to the small volume of water within them, so that the density of the water is rapidly reduced. At the same time the two large tubes which connect the upper and lower cylinders are filled with water of the original density, thus more than balancing the weight of the contents of the generating tubes, and causing rapid circulation. The discharge from the tubes into the upper cylinder is a mixture of steam and water, and these elements are separated as they flow over a curved baffle plate, which is placed immediately under the openings of the tubes, and incloses a considerable space above the water surface protected from spray, and from which the steam is taken.

The absence of leakage may be briefly explained as being due to the facts that the tubes can expand freely and that their connections with the upper and lower cylinders are not exposed to the heat of the fire, while in fire-tube boilers the part of the tube exposed to the most severe heat is its junction with the tube plate, around which there is no water to cool it.

Opinions have been expressed that this boiler will have but a short life. Opinions on such a matter are not of much value, and the author thinks that it will be of interest to the Institution to learn how the boilers of this type which are already at work have stood the test of time. The first one was made for the Congo Mission steamer Peace. The vessel was tried on the Thames in 1883, then taken to pieces, the boiler included, and re-erected in Africa by the Rev. George Grenfell, with black assistants only. She commenced work on the Congo in the spring of 1884, and has performed continual service since. The last news we had of her was contained in a letter from Mr. Grenfell dated the 18th of September last. He says: "The boiler itself is doing splendidly, and we have no difficulty in keeping up steam sufficient for 400 revolutions; in fact, quite steam enough for any purpose, and when head to wind often too much."

The next boiler was fitted in a second class torpedo boat for the British navy, and tried early in 1886. It has therefore been at work for about three years. I obtained permission from the Admiralty to remove some of the small tubes for ascertaining their condition. These specimens were cut out recently, and are exactly in the condition in which they were taken from the boiler. In examining them I was exceedingly pleased to find that the deposit in them was so very small in amount. It appeared possible that this boiler might fail, from the tubes becoming obstructed by deposit, and as it is impossible to gain access to much of their interior, this would have been a very serious drawback. I am not aware that the boiler from which these tubes are taken has been treated with any special care; the surface condenser is of the ordinary kind, and is not specially made to prevent leakage.

A few of these tubes, however, are not in such good condition as I had hoped; oxidation seems to have taken place to a slight extent within them, and the external surface of those taken from the outer rows has been very much rusted, and seems to indicate that these tubes have been wet for a considerable period. This is corroborated by the fact that the plates forming the external casing are also decayed in places. It is most satisfactory, however, to find that the tubes in the flue, and also those forming the firebox, are in most excellent condition. The blue scale is still visible on the outside, and the parts of the tubes exposed to the most intense heat do not show the least trace of injury from the fire.

The next examples are the boilers of the Ariete and Rayo. It will be remembered that an exceedingly high speed was attained in these vessels, due largely to the lightness and steaming power of the boilers, of which each boat had two. They were delivered to the Spanish government in August, 1887. Very soon afterward, newspaper reports appeared as to defects having manifested themselves, and it was stated that the boilers were condemned, and were to be replaced by others of locomotive type. We had no communication made to us officially concerning these alleged defects.

Seeing in the newspapers an account of certain manœuvers in which these and other torpedo boats were engaged, where it was stated that one of the boilers of the Ariete was disabled, we applied to the minister of marine for permission to send an engineer over to examine the boilers, and to put right any defects which had arisen.

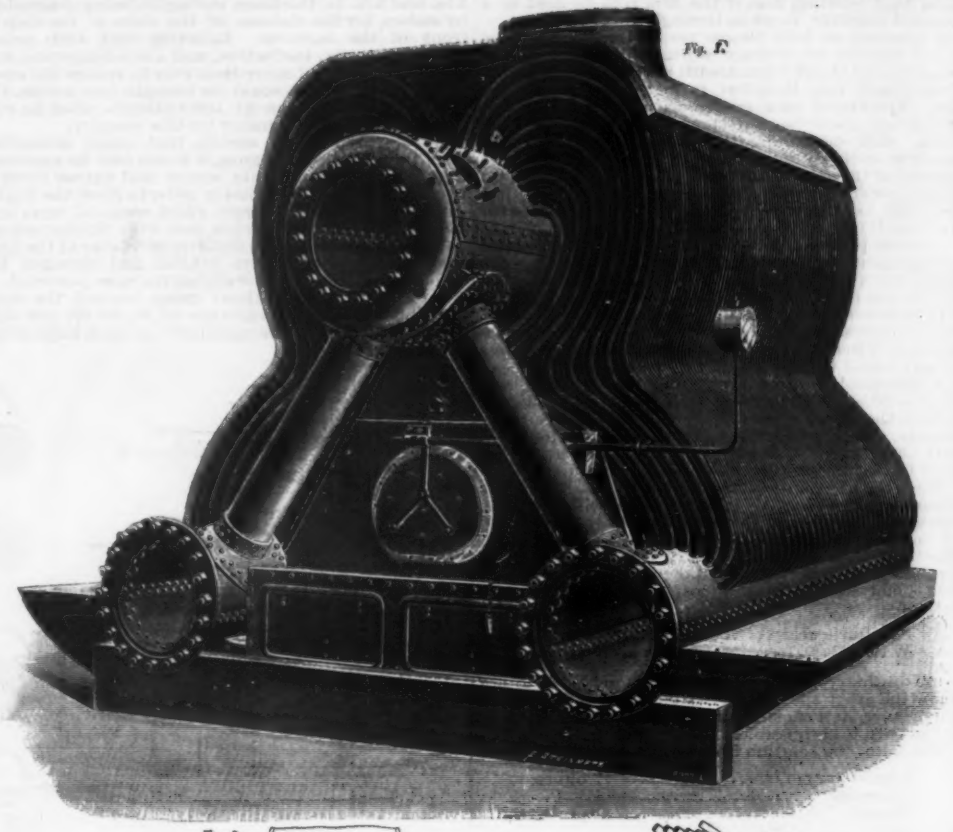
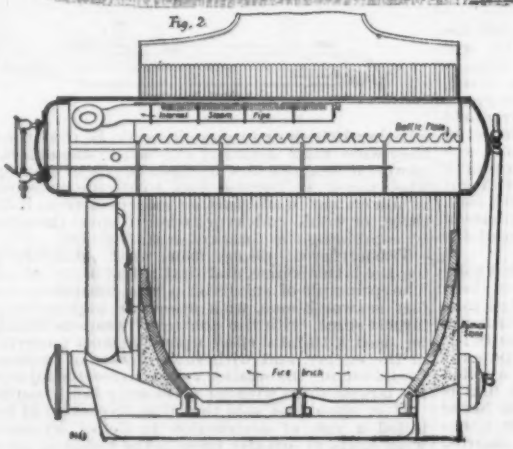
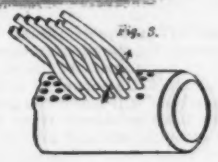
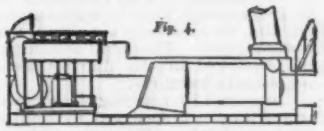
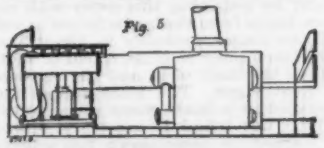


Fig. 1.









THE THORNYCROFT WATER-TUBE BOILER.

* Paper read at the Institution of Naval Architects.

After much delay this was granted, and our engineer reports as follows:

"The work of removing pipes, casings, etc., was commenced March 15. On removing the front and back plates of boiler casing, all the small tubes were found covered with a coating of soot from ⅛ in. to ¼ in. thick. I then caused the side casing to be removed; when this was done the lower parts of the casing (adjoining the coal bunkers) were found wasted away, caused by small coal, ashes, and soot being allowed to accumulate to a depth of about 5 in., the steam-cleaning gear pipes being embedded and partially destroyed.

"The front frame plate carrying the ashpan doors was then removed, and I found the ashpans firmly fixed in a bedding of small coal and soot which had been allowed to accumulate; this had to be dug away before the ashpans could be removed, and through this accumulation it has, to some extent, corroded the sides of the ashpans. On going inside the firebox I found the firebricks much damaged, and they have been in this condition for some time; those on the port side will have to be removed. The center firebrick on the inside of end casing, nearest the safety valve end of boiler, is missing, and from the crumpled appearance of the plate, has been in this state for some time. The inside of separator tube and collector tubes are very fair, no appearance of pitting being discernible, although the collector tubes have a deposit on the bottom of ⅛ in. of lime, etc. The separator dash plates (zinc) have wasted in their thickness from ⅛ in. to ¼ in. on the part that has been in the water, while the upper parts have a great deal of sediment fixed on them. The zinc bars in the collector tubes are but slightly worn.

"I have examined the safety valves and stop valves, and these are in a very fair condition. This day I have tried the small tubes with water, and have discovered one tube in the row marked I, or the second row counting from the top center of separator, and it is the eleventh from the safety valve end of boiler; this is the only one I have discovered, and it is caused through a small hole in tube about ¼ in. in diameter. I propose to draw this tube and refit a new one, to remove all sediment from the collector tubes, clean zinc dash-plates and bars, refit new firebricks, well cleanse the outside of small tubes from the soot, and remove the damaged parts of side casings, and fit strips of plate 8 in. deep to take the place of damaged parts.

"I would add that there is nothing in these repairs, excepting the damaged tubes, but what could have and should have been done by the stokers belonging to the ship, but which, from the total neglect the boiler has received, has very seriously impaired the efficiency of the boiler, until the neglect is rectified. In reference to the damaged tube, there are a number of special plugs supplied with the boat for the purpose of putting out of use any defective tube or tubes. Had this been applied—and the application of it is very simple—no annoyance would have been experienced, except instead of 918 tubes there would have been 917. From the general appearance of the boiler and fittings, it shows it has been greatly neglected, for in addition to the steam-cleaning gear there are brushes applied to assist; these have not been used, nor have the end plates been removed for this purpose, nor for inspection, since the boat left England."

The next vessels in order were the Danish torpedo boats Storen and Soloven, delivered in 1887. Since then we have supplied water-tube boilers in all the new torpedo boats built for that government, and are now replacing the locomotive boiler in a boat 5½ years old with two water-tube boilers.*

* Figs. 4 and 5 are diagrams illustrating the saving in space effected by the substitution of Thornycroft's water-tube boiler for a locomotive type boiler in the steam yacht Gitana.

	Old Boiler.	New Boiler.
Grate surface in square feet	16·2	22·7
Heating surface, firebox	51·87	78·0
" " tubes	653	1335
" " total	705	1410
Weight of boiler in tons	6·25	5·9
" water in boiler	1·87	1·35
Total weight	8·12	7·25

Careful experiments have recently been made by Professor Kennedy on one of these boilers, in order to ascertain the evaporative efficiency at different rates of working. The best result was with natural draught, when the evaporative duty reached 13·4 lb. of water per pound of coal, from and at 212 deg. The calorific value of the coal, as determined by analysis, was 15·41 lb. per pound of coal. The efficiency of the boiler with natural draught was therefore 87 per cent. of the theoretical evaporation, which we have reason to believe is the highest on record.

FIG. 12.—FRENCH EXCAVATOR, "DOWN DIGGER" TYPE.

[Continued from SUPPLEMENT, No. 700, page 11179.]

PLANT AND MATERIAL OF THE PANAMA CANAL.*

By WILLIAM PLUMB WILLIAMS, Jun. Am. Soc. C. E.

EXCAVATORS (Figs. 12, 13, 14, 15, 16).—Many styles of the endless chain of bucket excavators are in use, but after a thorough examination as to machinery and work accomplished, I consider the machines constructed by P. De Mange and Messrs. Satre & Lyons superior to any others. This machine is constructed on two trucks of four wheels each and of a 5 foot gauge, while when in working condition the working base is broadened by jacking up and throwing the weight on the working side out to a third rail 7 feet distant from the line rail. In transporting the machine from place to place the construction track of 5 foot gauge is adequate, and in working a third rail is laid up and down the line over which the machine is to travel. The ladder over which the buckets travel is hung on an axis on the back of the machine, but throws the center of gravity toward the working side, and to offset this, ballast of railroad iron is loaded on the extension on the back of the machine. The boilers are usually horizontal, giving low center of gravity, and the water tank of iron and a coal bunker of iron are placed on the boiler end of the platform. There are two styles of attacking a bank, called "down diggers" and "up diggers," whether attacking material above or below level of track. A "down digger" of the above manufacture at work at Tavernilla may be described as follows, Fig. 12. The endless chain of buckets operated on "over and under" system received their motion from the square upper tumbler of the shaft, which was geared from its wheel of large circumference, connecting with a smaller gear wheel on the crank shaft. The vertical engine supplied this shaft with three pistons, giving a positive motion. The buckets were constructed with a quadrangular hemispherical face and no back,

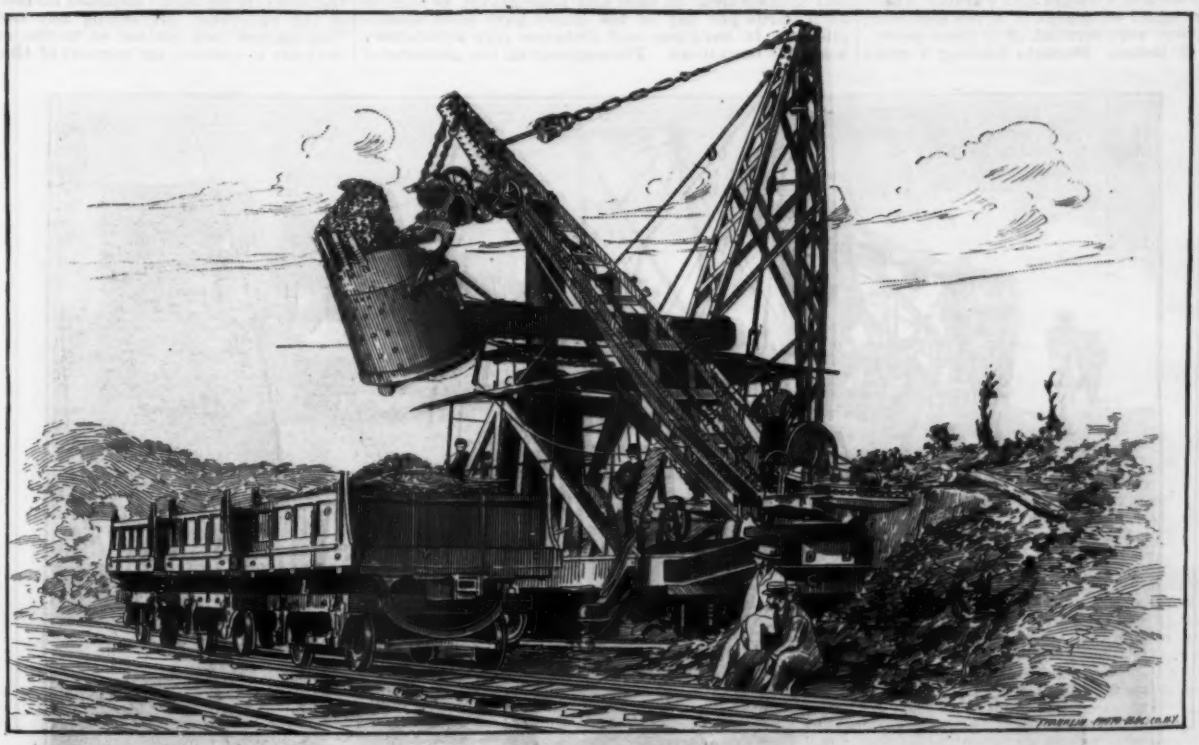


FIG. 13.—OSGOOD AMERICAN EXCAVATOR.

* A paper read before the American Society of Civil Engineers, July 2, 1888. From the *Transactions* of the Society.

the links being hung at the back of the bucket, and the ladder being suspended down the bank, was raised or lowered to give a slight contact to the cutting nose of the bucket, which became filled by gradually cutting a slice all of the way up the bank, carrying the material up and on to the upper tumbler shaft, and as the bucket at a slope of 45 degrees to the horizontal changed its angle by going over the upper tumbler, no support was given to the contents, which fell out and down into the hopper, and through a chute suspended over a train of dump cars on the second track and back of the machine.

The engineer of the excavator controls its movements entirely, raising and lowering the ladder, also moving the excavator up and down the track by an endless belt running from a sprocket wheel on the crank shaft of the engine to a sprocket wheel on car axle. With good executive management and a constant supply of cars under the chute this machine could excavate 200 to 300 cars per day of 6 cubic yards each.

The force necessary to work is as follows:

1 engineer	$5	per day.
1 coalman	2	"
1 fireman	3.50	"
3 carmen	2	each per day.
1 chainman	2	"

In connection with the excavator would be needed two locomotives, with fifteen to twenty cars each, depending upon the distance to the dump from the center of excavation. The consumption of coal is 3 tons per day. In sand and soft clay and dirt the machine will do efficient work. The stability of the machine is also controlled by clamping the frame of the machine on the rear to the track.

THE OSGOOD EXCAVATOR (Fig. 13).—I saw three of these machines at work at Culebra and Paraiso, which were among the original shipment of seven sent from America. The boilers were vertical, of 50 horse power, cylinders 10 by 12 inches. Buckets holding 2 cubic yards, struck measurement. Cost was $8,000, f. o. b. at Albany, N. Y. The working force was as follows:

1 engineer	$4 to $5	per day.
1 dipper tender	2.50 to 3.50	"
1 fireman	1.75	"
6 men shifting track, carrying water, etc.	1.50	"
Consumption of coal	1½ to 2 tons.	

This type of machine is supported on two trucks of 5 foot gauge, and when in position for working, the forward truck of the machine is jacked up, throwing the weight off the rails, and the outriggers of 8 foot centers are used instead, giving a wider working base. The weight of these large type of machines is about 30 tons. Self-propulsion is gained by an endless belt connection with the main engine shaft to the rear axles. Water tank and coal tank are placed on the rear car near the boiler. These machines will excavate a cut up to 70 feet in width, and dump contents of dipper 29 feet above track. The mode of action is for the excavator to start at face of cut and gradually excavate forward and on each side, of sufficient width for the placing of two tracks, one on each side of the excavator, which may move forward in reaches of 8 feet, each digging her own track. Dump cars are brought in alongside on either track from the rear switches by cable connection winding around a drum on the exterior of the body of the excavator. These cars when filled are hauled out on to main line, and empty cars are in readiness to supply their places. The dipper delivers first on one side, then on the other, the cars being constantly supplied. Under favorable conditions and management, in sand and loose gravel, as high as 2,000 yards per day of ten hours have been accomplished. In hard-pan and obdurate clay satisfactory work has been done. The engineer on the platform of the car operates the engine, lowering or raising the dipper, swinging it around on to the cars, while the dipper tender standing on the turn-table crowds the dipper to its work and empties it. I found in all cases the "Osgood" machine spoken of in the highest terms, as doing a larger amount of work with less force of men and less liability to get out of order than those of foreign manufacture, and the fact that it was able to help itself, preparing its own track, enables it to work in all places where the endless-chain-of-bucket type would be useless.

EXCAVATOR "UP DIGGER" (Fig. 14).—These machines are made to receive their power in two ways from the main engine, by direct connection of piston to crank shaft, on which are balance wheels, and two small gear wheels gearing into wheels of large diameter on upper tumbler shaft. This supplies a positive power, so important for a machine at work in stiff clay and hard-pan. The other means of doing this is applied in the Suez Canal type of excavator, which receives power by the sprocket-and-chain connection already described as used on the French dredges.

In the "up diggers" the buckets are constructed similar to buckets of the dredges, and have the under and over movement.

The weight of these machines runs as high as thirty-six tons ready for work, and to this must be added the weight of the dirt of one-half the number of buckets filled, so in many cases the weight will reach fifty tons. In the larger type a third rail is placed seven feet from the rail on the "line side," thus throwing the weight of ladder and derrick on the outer rail, while clamps on the line side are easily adjusted on the track and body of the excavator, preventing any overturning. The "up diggers" are limited as to the amount of work they are to execute, on account of the short length of ladder in use, and the track must be constantly "thrown," in order to give a steady working contact with the bank. In working "down diggers" and "up diggers," a supply of cars should always be on hand, so that when one train is loaded and starts off for the dump, its place may be taken immediately by a second train. This item is alone important in the capacity of work of a machine, and a foreman of intelligence

FIG. 14.—FRENCH EXCAVATOR, "UP DIGGER" TYPE.

FIG. 15.—EXCAVATOR AND TRANSPORTER.

should always be placed in charge, so to regulate switches and side tracks as to cause no demurrage. In the rainy season it has been found impossible to keep up the tracks at Culebra and Tavernilla, and the excavators have all been abandoned and cranes substituted. The "down digger" machines rest on the edge of the terrace, and the slope, inclined at an angle of two to one, is not flat enough to prevent a sliding tendency of the bank caused by a 50 ton weight and a vibratory movement arising from the contact of the bucket with the bank. With the "up digger" at work in the rainy season the same sliding occurs, the limited swing of ladder (in many cases the working side of machine being only ten feet from the perpendicular bank, which caves and slides) causes the tracks to be covered up.

EXCAVATORS AND TRANSPORTERS.—At Tavernilla, in connection with the endless chain of bucket excavator, was employed a transporter (Fig. 15). A truss of 500 feet in length was supported at one end on the deck of the excavator, and extended at right angles to the fore and aft line of work, the other end being supported upon a traveling derrick and car. This truss was six feet in width and ten feet in height, and an endless belt 4½ feet wide received motion from an independent engine of the excavator. The contents of the buckets of the excavator were discharged into the hopper and out on to this traveling belt, thence along over top of truss until the end was reached, when, the belt going over the outer tumbler, its contents fell to the ground. The outer end of the truss may be raised as high as 90 feet from the ground, giving room for a large bank to fall without obstructing the passage of derrick car from the debris sliding toward the machine.

In this work the excavator was digging 30 feet below the rail of the car; material was carried 500 feet distant and elevated a total of 50 feet. This necessitated the keeping up of three tracks, the two tracks of excavator, and a track of platform car, supporting belt, engine and boiler, and track of derrick car. In addition to the regular crew of the excavator, there were used one man on the derrick car to preserve a constant forward motion up the track with the excavator, one engineer on the platform car to regulate belt engine, and one fireman each for derrick car and platform car. The use of this extensive plant is limited to the following case: In deep cuttings, where a depth of over 50 feet is to be made and over a length of several hundred feet, it is necessary to throw the material so far back from the center as to be outside of the slopes when the requisite depth is obtained. In this first cutting of 30 feet, throughout width and length, the material may be handled automatically and deposited by the transporter, but here its usefulness ends. In the second cutting of 30 feet the material must be hauled away by cars, and tracks constructed up and out of the cut, and to some dumping ground, as in going down deeper with the excavation the dump rises vertically, and the transporter would be at too great an incline to work economically.

CLAPETS.—The self-dumping steam clapets were all of French construction, the hulls in many cases being constructed in sections in France and sent over to the Isthmus and set up at the foundries and shops at La Boca and Colon. The capacity varied in instances from 150 to 300 cubic meters, the length of hull being from 75 to 120 feet. Propulsion was from the aid of twin screws, and the draught of water when loaded 10 feet and under. These machines were supplied with hinged doors on the bottom of the scow, opening outward, and were opened and closed by chains on the hoisting engines. They are much easier handled than self-dumping scows operated with tow-boats, and the time occupied in running up to the dredge and making fast is reduced to a minimum, usually attaching and detaching in ten minutes. The cost of these clapets was as high as $20,000 constructed on the Isthmus. The complement of men was as follows:

1 captain	$200	per month.
1 mate	120	" "
1 engineer	120	" "
1 cook	60	" "
2 firemen	50	" "
10 deck-hands	45	" "
1 donkey engineer	45	" "

The contractor supplying board.

HOUSES FOR MEN.—The common type of quarters for men along the line of the Panama Canal was to erect a light framework of wood, the sheathing being horizontal and of spruce, the roof of corrugated iron, and either round or peaked. Stationary beds were erected for the men through the center of the house in rows of two deep, and houses of 50 by 30 feet will accommodate 40 men. The foundation was constructed of rough ashlar masonry or concrete in piers located under the corners, quarters and centers of the floor, in most cases the house being raised high enough to allow free circulation of the air underneath. "Flying houses" are frames built of light angle iron with corrugated iron roof and sidings, and are largely used for machine shops, when the use will be temporary. They

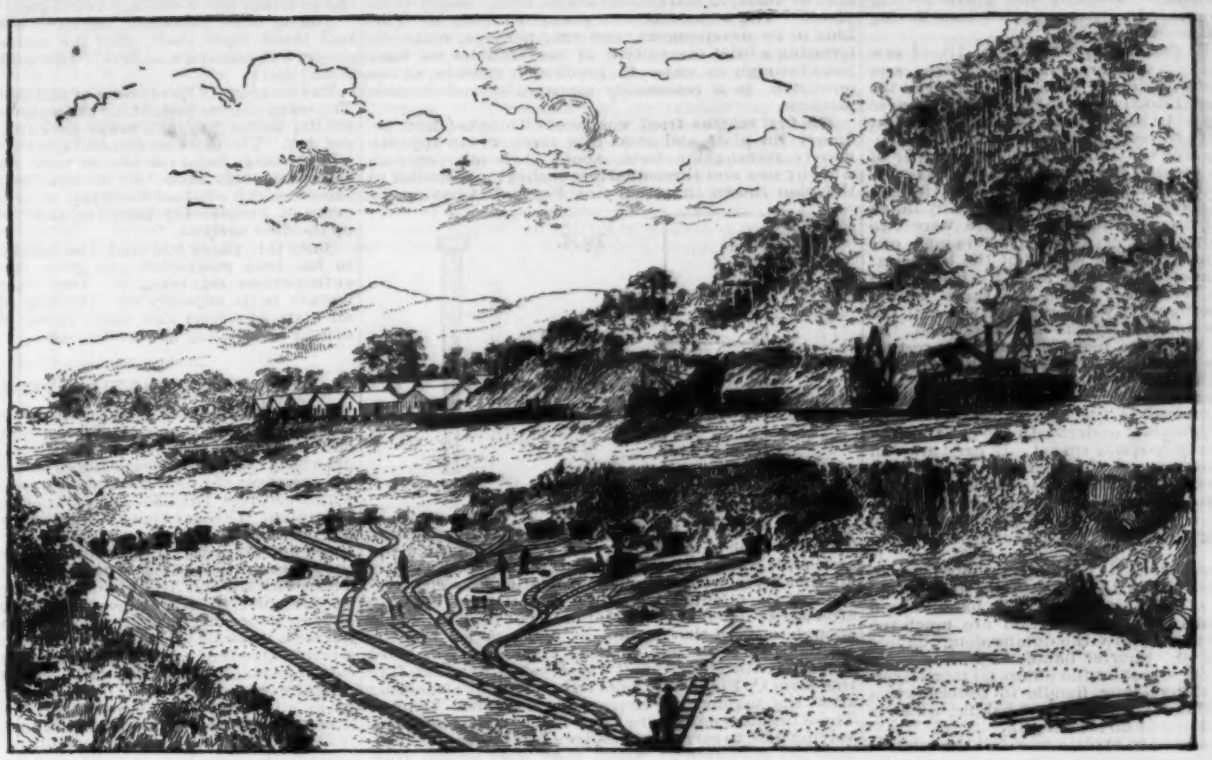


FIG. 16.—PARAISO SECTION, FRENCH AND OSGOOD EXCAVATORS.

FIG. 17.—ROCK CUT AT OBISPO—EVERARD DUMP CARS.

can be easily taken apart and transported from place to place by removing the bolts holding the sections, while with wooden structures, nails and bolts being used, the timbers would become broken, split and decay in a short time. Tile roofs are much cooler than corrugated iron, but more expensive, while shingles decay in a year's usage. Asbestos and gravel roofing have not stood repeated tests, corrugated iron having given the best satisfaction.

DUMP CARS—EVERARD SYSTEM (Fig. 17).—I saw many wooden systems of dump cars, built in some cases of creosoted wood in order to resist the action of the climate, but I found upon examination that all cars so constructed did not last as long as those built of wrought iron. The body of the car, being subjected to the concussions of heavy weights falling from the hopper of excavators, soon became fractured. These cars were constructed of 5 foot gauge and four-wheeled, the axle and framework and body of cars being easily taken apart and occupying small space. There were two sizes of bodies, one holding 4 cubic meters and one holding 6 cubic meters. The weight of the larger car was 5 tons unloaded, and when loaded with 6 cubic meters of earth, 10 tons. When the car is evenly loaded, the center of gravity is well preserved and the car may be easily dumped by the aid of two men. At each end of the body is a hemispherical cam, resting vertically upon a track supported upon the frame of the car, so that the body is allowed to move through an arc of 45 degrees. One serious objection which may be easily remedied is the use of a buffer in one continuous piece, running underneath the car and connected by a lug with a spiral spring. If cars are run into, the concussion causes the buffer to retreat, and the motion is not sufficiently counteracted by the spring, it being too light, and consequently the buffer from the shock is knocked out of place, retreats to rear, and striking the buffer of the second car, a buckling occurs.

I would suggest that this spring be doubled in strength, and the buffer then would be enabled to stand the shock of adjoining cars. The handles used to keep the car in a horizontal position are much too long and often strike against the dumps along the line when not leveled off. Shorter handles would be more effective, as in a car upset on the dump no more leverage is gained in using a long handle to restore it to a normal position than by using a short handle, which is more rigid and admits of no lateral pull.

I have not attempted to explain in detail the relative merits of the different machines, but have only described the plant doing the most effective work, and later in the year I hope to present a paper on the "Dredging Appliances" in use on the Panama line, with detail drawings of each and a history of their work.

The same machinery in use on the Panama line, when worked by intelligent Americans and operated by American contractors, would accomplish a larger ratio of work; but this will never occur, as the climate alone forbids the economical employment of any number of skilled white men.

(To be continued.)

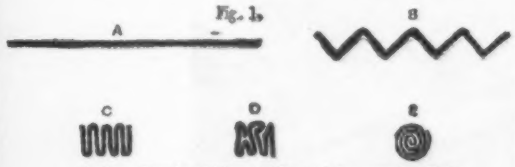
NAILS FROM TIN SCRAP.*

By OBERLIN SMITH, Bridgeton, N. J.

IT may surprise the learned metallurgists who read this paper to learn that, by a recent discovery, nails of good quality can be made at one operation, directly from the ore, at the rate of, say, sixty per minute for each operator. It should be stated, however, that the raw material referred to does not answer strictly the ordinary assayer's definition of an ore. It is found, in strata of various thickness, in Harlem, N. Y., and other localities where the *debris* from restaurants and from sheet metal factories of various kinds has been dumped. In other words, it is old and new tin scrap—one of the few substances which this generation, mainly occupied in exhausting the accumulated resources of the past, seems to have laid up, by way of atonement, for the benefit of posterity. In speaking of this material as *ore*, we are simply looking forward, prophetically, to the time when our descendants may dig it up and write learned papers for the American Institute of Mining Engineers upon the best methods of assaying and smelting it.

At least such has seemed to be its destiny hitherto. It may fairly be said that the many attempts that have been made to utilize it by separating, through chemical or electrolytical processes, its two valuable constituents, metallic tin and first-class wrought iron, have failed, either technically or commercially. The reasons for such failure need no there be discussed. Either the separation has been incomplete, the iron still retaining enough tin to spoil it for the sinking fire, or other use short of remelting (perhaps even for that), or the manipulations of the process have been too expensive to make its results profitable—or both. Meanwhile the great tin scrap deposits have gone on growing faster than any other strata of our Post-Tertiary, Psychical

Fig. 1.



Sections Showing Different Ways of Compressing Blank.

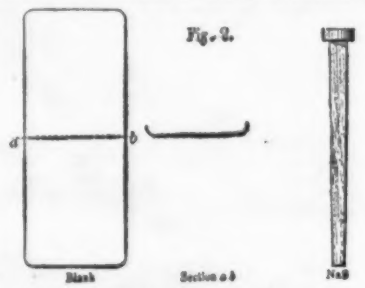
Era; given up by metallurgists, not yet attacked by geologists, and explored only by that mining engineer of the transitional period, *Gulielmus Caper*.

Before leaving these heaps of tin scrap, however, to become mere mineral deposits for future ages, it may be well to consider a novel plan for their immediate utilization—novel, not only in its means, but in its principle. For it undertakes to use this material just as it is, without trying to separate its constituents at all, and to use it, moreover, for a purpose in which the qualities of both these constituents, namely, the tensile strength and ductility of the iron and the resistance of the tin to corrosion, are directly employed with advantage. I refer to the manufacture, by mechanical pressure, of nails.

This nail was invented, in its original shape, by Mr. Geo. H. Perkins, of Philadelphia, and has been developed, through various forms, until it has almost reached a commercial stage—the machine in which it is to be made, in marketable shape, being nearly completed. The writer has been associated with Mr. Perkins in its development, and can, perhaps, make interesting a brief description of the troubles we have gone through in order to produce it quickly, at one operation, in a reasonably manageable and durable machine.

The first scheme tried was to cut "blanks" from ordinary tin plate and sheet-iron scrap, of an approximately rectangular form, about three-quarters inch wide by one and three-quarters inches long, similar to the plan shown in actual size, Fig. 2, but having the

Fig. 2.



Blank and Finished Nail, Full Size.

end section A, Fig. 1 (drawn about twice its real size). This was done in an ordinary press. By a second operation, it was corrugated into the form B, Fig. 1, in another press, with a special automatic die, which corrugated the middle grooves first and the side grooves afterward; much of the metal used not proving strong enough to stand the friction of being pulled into the corrugations of the die without cracking. At a third operation, the embryo nail was crushed together into the form C, Fig. 1 (but more tightly closed), something after the manner of closing an accordion bellows. These headless nails were then fed by hand into a revolving dial, to carry them under a heading mechanism, after the operation of which they were ejected from the machine automatically.

Obviously, this series of separate operations made the nails far too expensive for the market; and, moreover, some trouble occurred from their splitting in the tightly folded corrugations. We afterward built an *automatic* machine which performed all the above operations in succession, delivering a complete nail at each stroke. It was, however, far too complicated for practical use, and simply served to show what could *not* be done.

Our second nail machine proper, constructed to receive blanks which had been already cut in an ordinary press, worked fairly well. It was likewise an experimental machine, built "piecemeal," and not strong enough for continual hard work; but it served this time to show what *could* be done. Instead of working upon the principle of regular corrugations, it simply crushed up the blanks edgewise into any form which they chose to assume—the end sections appearing somewhat as shown at D, Fig. 1. The blank and finished nail are shown in Fig. 2.

The machine now under construction has been very much simplified and made enormously strong and heavy. It is adapted to cutting, crushing, griping and heading the nails at one operation, and can be run as fast as an expert operator can feed the material. Its feed probably varies, with jagged, irregular scrap, from thirty to ninety nails per minute, although straight strips of sheet metal can easily be fed by hand into a machine running as high as 240 strokes per minute.

During the course of our experiments, various forms of nails have been tried. Among others were straight cylindrical nails with conical points; straight, square nails with pyramidal and with wedge-shaped points; hexagonal nails, etc. The most practical form, however, seems to be the square taper nail shown in Fig. 2, which has about the same shape as the ordinary cut nail, but is somewhat stronger and a good deal tougher. It is well adapted for all ordinary purposes, but is especially suitable for a roofing nail, since the tin coating prevents much rusting, and is good to solder to.

Among other processes, we have tried winding the nail blank upon itself, after the manner of a window shade, but minus a mandrel. This makes a very good round nail.

The economy of this system of nail making is obvious. The scrap can be bought for about seventeen cents per 100 lb., and a boy can make perhaps 100 lb. of nails per day. The most economical system of manufacture will probably be to run one or more nail machines at each large "tin shop," set as close as possible to the presses which produce the scrap, so as to avoid the expense of unnecessary handling and the extra tangling up incident thereto.

Since this paper was read, the nail machine referred to has been completed, and gives results beyond all anticipations regarding it. One especially valuable feature is its capacity for "chewing up," so to speak, all sorts of slivers and small pieces of scrap without danger of clogging the mechanism.

* A paper recently read before the American Institute of Mining Engineers.

THE TYPE-PRINTING TELEGRAPH.

HOWEVER valuable type-printing telegraphs may be as simplifying the transmission of intelligence, they are not without a serious, and for some purposes fatal, drawback. This drawback lies in the manner in which the messages are delivered, namely, on a band or tape which involves the handling of thousands of yards of the ribbon. This drawback it was that caused the House and Hughes machines, with all their advantages of speed and accuracy, to be banished from the offices of the telegraph companies both in England and America. This awkward and troublesome form of delivery has, we are glad to say, at length had the attention of Messrs. Moore and Wright, who have succeeded in producing a machine in which the message is delivered in a printed column, similar in appearance to a communication produced by an ordinary typewriter. The successful working of this machine was recently witnessed by us at the offices of the *Central News*, New Bridge Street, Blackfriars, London. This ingenious machine is illustrated in accompanying cuts, where Fig. 1 is a perspective view, Fig. 2 a front and Fig. 3 a side elevation, while Fig. 4 shows details of the parts for moving the paper a distance, and bringing the type wheel back to its starting point when a new line is to be commenced. It is a single wire machine, and its construction is simple, while its working is certain, noiseless, and wholly satisfactory. Quotations of shares, instead of being lost in a tangled mass of tape, are set in column form, pleasing to the eye and easy of reference. Items of news appear with heads, just as printed in a newspaper, while tabulated figures are arranged with precision and uniformity.

Turning to the construction of the machine, we may observe that, in order to obtain ease and speed of working, two clockwork trains are used, one to revolve the typewheel and the other to feed the paper upward at the end of each line, and at the same time returning the typewheel to its normal position. The paper feeding and typewheel returning clockwork is released by the action of an auxiliary magnet, which is of about two ohms resistance. To the armature of this magnet are attached two releasing fingers, which act upon a pin attached to a pinion at the last position in the train. On charging this magnet sufficiently to attract its armature, the fingers are merely moved into proper position, the paper not being fed until the current ceases, and the armature is withdrawn by means of a spring. This constitutes one special feature of the machine, the other being the mode of feeding the typewheel laterally, which is effected by means of two racks, one being fixed and the other movable. This is a very efficient arrangement, and so far as we are aware, is new in connection with printing telegraphs. In designing and constructing the column type-printing telegraph, Messrs. Moore and Wright have sought to

FIG. 1.—THE TYPE-PRINTING TELEGRAPH.

give the magnets as little work to do as possible. The clockwork trains, which do the bulk of the work, are released by the magnets, the latter acting with an ease and freedom not even attained in the ordinary tape machines. They have, moreover, aimed at the attainment of such simplicity as would necessitate little or no departure from methods at present employed in working the tape machine, and in this they have succeeded.

The details of this machine will be understood by a reference to Figs. 2 and 3 of our engravings. A and B are two barrels, each driven by a cord and weight. The barrel, A, by a train of spur gear wheels drives a spindle, C, on which the type wheel is mounted. The barrel, B, by another train of wheels, drives a roller, D, over which the paper to be printed on is led. On the spindle, C, are two escapement wheels, C^1, into which a pallet, E^1, actuated by an electromagnet, E, with armatures polarized by the permanent magnet, F, is made to engage alternately. When a current of one polarity is sent through the electromagnet, the armatures move in one direction, and when a current of the opposite polarity is sent, they are moved in the opposite direction. To rock the armatures, alternate currents are sent through the electromagnet by the transmitting instrument, which may be of any ordinary construction. The paper to be printed on is led from the roll, H, round the roller, D, and this roller, after the completion of each line, is allowed to be partly rotated, as we shall explain later on, to move the paper a distance equal to the distance required between the lines of printing.

Normally the roller, D, is, as usual, a slight distance off from the circumference of the typewheel, I, and each time that the printing of a letter is to take place, the roller is moved toward the typewheel, and the paper where it passes around the roller is forced against the type which is opposite to it. This is done by the roller, D, being rocked at each movement of the printing or impression lever, J. One arm of this lever carries the armature of an electromagnet, K, and is drawn by a spring, K^1, up to an adjustable stop, K^2. The alternate currents which pass through the driving coil also pass through the coils of the magnet, K, but are not of sufficient duration to cause this magnet to draw its armature toward itself until, when a letter is to be printed, a current of longer duration passes.

The typewheel, I, is carried by a sleeve, which can be slid endwise along the spindle, C, but turns with it. The sleeve can be moved along the spindle by a fork, which embraces it, and which extends from a carriage, M, which can be slid along a fixed guide rod, N. The carriage, M, carries two pawls, O (one behind the other), which engage with ratchet teeth cut on the edge of two bars, one behind the other, and the front one of which, P, can be seen in Fig. 2. The hinder toothed bar or rack is fixed. Each time the armature, carried by the lever, J, is drawn to the magnet, K, the ratchet bar, P, is moved a distance endwise, and the pawl, O, which rests on the rack teeth instead of resting on the tooth it was previously resting against, rests upon the next tooth, and when the printing lever returns to its original position, the ratchet bar is shifted in the opposite direction by a spring; it then drives back the pawl, and the carriage, M, with it, thereby shifting the typewheel sideways; as it is shifted sideways, the hinder pawl slips over the hinder rack, and drops into the next tooth of the rack, and so that the slide is prevented from moving back. In this way the carriage can be traversed step by step from one side of the machine to the other. When it arrives at the end of the traverse, it is brought back to its starting position by a cord, which passes from it to the circumference of a spring barrel. To allow the cord to draw it back, both pawls are simultaneously lifted and withdrawn from the rack teeth of the bars. This is done whenever the printing lever is moved at the time when a blank space on the circumference of the typewheel is toward the paper, and when a special key of the transmitting instrument, which causes the current strength to be increased, is depressed.

The movements are effected in the following manner: In circuit with the line is an electromagnet, K^3, whose armature, *k* (see also Fig. 4), is held back by a spring, *s* (attached to the pin, *c*), whose tension is such that it cannot be overcome except by a considerable increase in the normal current strength. To the armature are fixed two blades or stops, *a* and *b* (Fig. 4), one of which, *b*, is movable, and is kept pressed in the position shown by a spring. A pin, *c* (Fig. 2), fixed to and projecting at right angles to the axle of a pinion, *p*, which is in gear with the clockwork driven by the barrel, B (Fig. 3), normally presses against the movable blade, *b*, and keeps it back in the same plane with the fixed blade, *a*. When the armature, *k*, is attracted, and the blades moved, the pin, *c*, slips from blade, *b*, to blade, *a*, and blade, *b*, jumps forward under the influence of the spring pressing against it. When the armature is drawn back, the blades are again shifted sideways, but in the opposite direction; the pin, *c*, on the pinion axis then comes at the back of the movable blade, and there being nothing in the way of the pin, the pinion to which it is fixed turns until the pin comes on to the face of the blade, and brings it back into its original position; thus the further rotation of the pinion is prevented.

When the train of wheels connected to the pinion is thus allowed to turn, it revolves the paper roller, D (Fig. 3), and shifts the paper the distance that is required to be between the lines. At the same time it turns a notched or cam wheel, and one of the projections upon the cam wheel acts against a lever, and rocks it on its center. This movement of the lever causes a bar to be lifted which is parallel with and by the side of two ratchet bars, P, by which the typewheel is traversed sidewise step by step along its axis, as before explained. When the bar is lifted, it lifts both of the pawls which engage with these ratchet racks, and the typewheel is drawn back into the position for beginning a new line, the bar being held up by a spring catch until the typewheel has been brought into this position; the slide which moves the typewheel then comes against and liberates the catch, and the bar is drawn downward by the action of a spring.

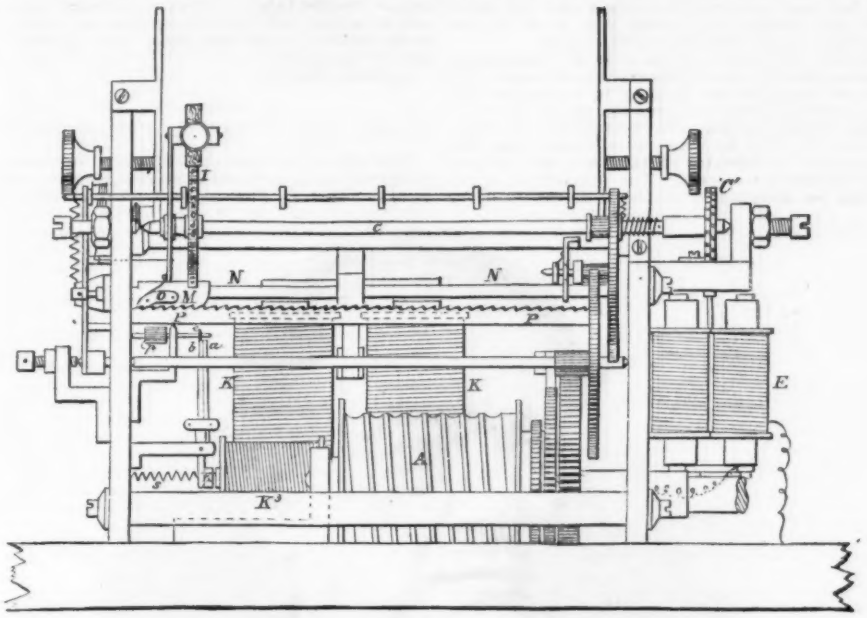


FIG. 2.

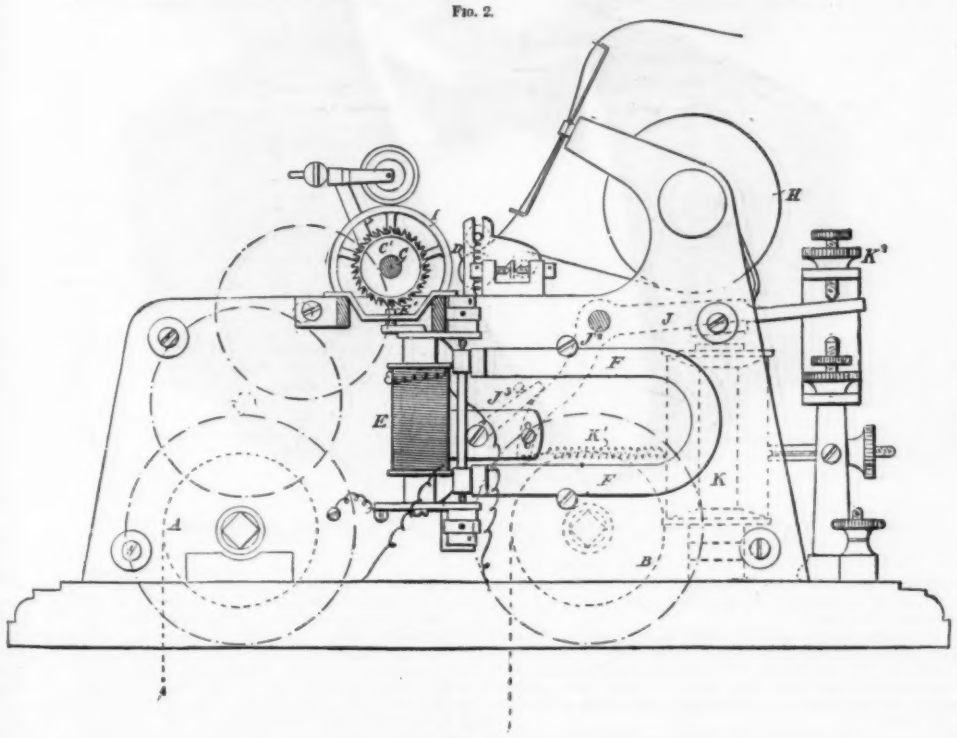


FIG. 3.

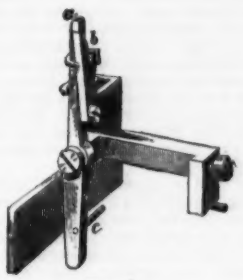


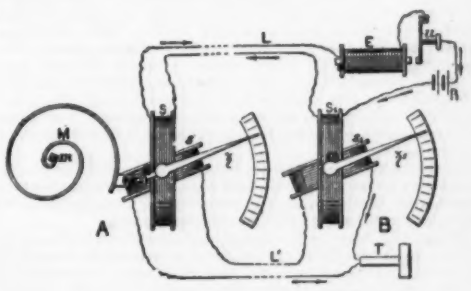
FIG. 4.

Where a large number of points are to be served, the method of operating this machine differs but little from the practice with the tape. A keyboard, simple in construction, controls any number of machines, while a dynamo in conjunction with accumulators supplies the current, each circuit of fifteen or twenty machines taking about one-third of an ampere. Such then is the column type-printing telegraph, which, so far as we are aware, is the only machine extant which fulfills all the functions of the tape while furnishing a record greatly superior.—*Iron.*

THE TYPE-PRINTING TELEGRAPH.

THE TELE-INDUCTOR.

MR. P. MOENNICH, of the University of Rostock, has just brought out an apparatus that is based upon a new idea, and which may be applied to the showing of the indications of all apparatus such as water-levels, thermometers, barometers, electric measuring apparatus, etc., located at a distance. The annexed figure represents the apparatus as applied to the transmission, from A to B, of the indications of a metallic thermometer, M. The transmission is based upon the extinction of an induced current in two identical and movable bobbins, connected in opposition and submitted to the inducing action of two stationary bobbins placed in the circuit of any electric source (induction bobbin or vibrator, E).



The first movable bobbin, *s*, is connected in an invariable way with the indicating apparatus, M, and the second bobbin, *s*, is shifted at the other station until the telephone, T, no longer renders any sound. At this moment, the position of the index, z_1, corresponds exactly to that of *z*. This arrangement is extremely ingenious, although it has certain drawbacks. Thus, four wires are required, or at least three on utilizing the earth for one of the return wires. Besides, the sensitiveness is not the same for all points of the dial. Toward the point of no induction, the position of the second bobbin, *s*, will be a little uncertain. Finally, it remains to know whether it is possible to obtain practically two pairs of identical bobbins.

As this apparatus is nothing else than an induction bobbin, it will be necessary at all times to take care not to leave pieces of metal near either of the bobbins. Mr. Moennich, however, has made numerous experiments with various specimens of the apparatus, and has convinced himself of their advantages and of the possibility of the use of them in practice. We are persuaded that this arrangement of a distance indicator will be able to render services in many cases.—*La Lumiere Electrique.*

[NATURE.]

NOTE ON THE USE OF GEISSLER'S TUBES FOR DETECTING ELECTRICAL OSCILLATIONS.

AT the suggestion of Prof. Lodge, I undertook to repeat in the Physical Laboratory of the University College, Liverpool, Hertz's celebrated experiments on electrical oscillations.

In performing these experiments, I was searching for means to make the effect of the electrical oscillations more easily observable, and I was induced to use for this purpose (1) Geissler's tubes, in order to strengthen the visible effect; and (2) the chemical action of the oscillating currents (paper soaked in solution of iodide of potash), in order to obtain a permanent trace of them.

For the present I will describe briefly the results of the use of Geissler's tubes.

In order to produce the electrical oscillations, I used a conductor consisting of two zinc plates, about 41·5 centimeters square, suspended in the same plane 55 centimeters apart; to each plate was fastened a No. 6 copper wire, which was finished off with a small brass knob The two brass knobs were about 5 millimeters apart, and formed the *sparking gap*, as we shall call it. As receiver of the oscillations, I used, like Hertz, circles of No. 14 wire, 35 centimeters in radius.

After the example of Mr. F. T. Trouton (*Nature*, February 21, p. 391), I will call the first conductor a *vibrator*, and the wire circles, or other receivers, reasonators.

The vibrator was connected with a small coil, 20 centimeters long, supplied with an ordinary spring interrupter, and excited by four secondary cells.

If we connect one electrode of a convenient Geissler's tube with either side of the sparking gap of the resonator, currents pass through or into the tube, which lights up and so makes the effect of the electrical oscillations on the resonator visible even at a great distance.

Of the few tubes which were at my disposal, I found that the most convenient for this purpose was a small one with electrodes 8·5 centimeters apart, and filled with highly rarefied air. But spectral tubes 30 centimeters long and filled with hydrogen, oxygen, or nitrogen also gave good results.

With the first mentioned tube I perceived *a visible effect*, when the resonator was held horizontally in the plane containing the wires of the vibrator, and with the sparking gap turned toward it, at a distance of 4 meters from the vibrator. By this arrangement all the phenomena described by Hertz (*Wiedemann's Ann.*, xxxiv., p. 160, 1888) about the direction of the electrical lines of force can easily be shown.

A very instructive experiment is to show the directions of these lines by several resonators disposed round the vibrator. For this purpose I suggest the following apparatus:

On a wooden frame mounted so as to be able to revolve on a vertical axis standing under the sparking gap of the vibrator are fastened several resonators, with their planes vertical and parallel respectively to the directions of the lines of force and the sparking gaps at the highest point. These resonators are supplied with Geissler's tubes. In this position of the resonators all the tubes will lighten up when the vibrator is working. But if the frame with the resonators moves round the vertical axis, the light of the tubes will become weaker, and, when the frame is turned 90°, the tubes will become quite dark; the planes of all the vibrators in this position being perpendicular to the directions of the lines of force. This change will occur inversely by turning the frame from 90° to 180°.

If instead of one resonator two are fastened to each point of the frame, one perpendicularly to the other, both being vertical, the changes in either of these will be contrary—that is to say, when the light in one set of the tubes becomes brighter, it becomes weaker in the set perpendicular to it, and *vice versa*. Thus the strength of the light is, so to say, proportional to the magnitude of the components of the lines of force in the direction of the tubes.

If a disconnected Geissler's tube is held near the vibrator, it begins in a short time to light up, owing to oscillatory currents passing through it. The same effect is obtained if instead of holding the tube by the hand it reposes on an insulating body. This lighting occurs at all points near the vibrator, except about the sparking gap. The tube becomes quite dark if the hand or a conductor is interposed between it and the vibrator; on the contrary, the interposing of an insulating body causes no change in the tube. The tube becomes more sensitive if a portion of it is surrounded with tinfoil.

In this way the existence of electrical oscillations in space can be ascertained, and also the transparency of insulating bodies and the opacity of conductors for electrical oscillations can be demonstrated.

When the two electrodes of a Geissler's tube are connected with two different points of a resonator, the effect in the tube is produced by the difference of potential of the two points. If now we connect one point of the vibrator or the resonator with one electrode of the tube, the other electrode hanging free in the air or being earthed, we have an alternative current through the tube whenever the potential of the point connected with the electrode becomes different from zero, and thus the tube lights up. The effect is strengthened if one portion of the tube is surrounded by tinfoil. This is a very convenient arrangement for observing the form of the electrical oscillation in conductors.

If we investigate in this manner our circular resonator held vertically before the vibrator, with its plane parallel to it and the sparking gap upward, we find that a tube hanging at the lower end of the vertical diameter of the circle, opposite to the sparking gap, remains quite dark, and lights up when moved to the right or to the left of this point. The light becomes brighter till the horizontal diameter is reached; further on the light begins to grow weaker till the sparking gap is attained, where the tube, however, continues to lighten. The light becomes weaker when the sparking gap is narrowed, and ceases when it is quite closed. Thus we see that the circular resonator possesses one node at its lowest point, two ventral segments at equal distances from the node and the sparking gap, and two minima of oscillation, one on each side of the sparking gap.

That a node is situated at the point opposite to the sparking gap is also ascertained by observing that, by touching this point with the finger, or by hanging from it a piece of wire, or by connecting it to earth, no change is to be remarked in the spark of the resonator. These manipulations, if applied to another point of the resonator, diminish the spark.

If the resonator is formed by a closed circle of wire, we find a node at each end of the vertical, and a segment at each end of the horizontal, diameter of the circle. The distance between the two nodes being here 110 centimeters, the wave length is 220 centimeters, while the length of the primary wave is about 880 centimeters. Thus the wave length in the resonator corresponds to the second higher octave of the fundamental oscillation.

If, instead of circular, we use linear resonators placed parallel to the vibrator, we must be very careful to distinguish between the effect produced directly from the vibrator in the Geissler tube and the effect caused by the oscillations of the resonator. In the case of the circular resonators, placed in the position above described, one need not trouble much about the direct effect of the vibrator, this being very small in the neighborhood of the vibrator's sparking gap.

To prevent the direct action, a small uninsulated metal screen can be placed between the vibrator and the tube, or the tube can be hung by a long and fine wire, in order to be removed from the sphere of the direct action of the vibrator. The best plan is, however, to surround the tube by wire gauze, which stops the direct action of the vibrator on the tube, and yet permits the tube to be observed. The absence of direct action can be ascertained in the different positions which the tube takes by insulating it from the resonator without changing its position, and noticing if it becomes quite dark.

If we place before the vibrator a resonator, consisting of a straight wire 220 centimeters long (I used copper wire No. 6), we find, by the tubes, that nodes exist in the middle and the two ends of the wire, consequently two segments at 55 centimeters from each end of the wire.

(The above described circular resonator can be likened to a linear one which is curved to a circle and its two ends soldered together, thus the two nodes of the ends becoming one single node.)

If this straight wire is cut in the middle, a torrent of sparks passes between the separated ends, even if they are removed several millimeters apart. If then we examine each half of the wire, we find that it possesses a node in the middle and two segments, each at one end, but the node is not so well defined as in the case of the uncut wire; there is no single point the potential of which remains continually equal to zero, but a line in which the difference of potential from zero is a minimum. This complicated form of oscillation is produced by the fact that the forces acting in this resonator are not equal at all points or symmetrically distributed with respect to it, as in the case of the long resonator. The oscillations of the short resonator may be compared to those of a rod which is not firmly fixed by its middle. The state of these oscillations is not stable. If one or both ends of this resonator are touched by the finger, they become nodes, and a well defined segment appears at the middle of the resonator. If the Geissler tube be connected with this middle point, it begins to light up when the ends of the resonator are touched, and ceases to light the moment the fingers are removed; the contrary takes place if the tube be connected with one end of the resonator. This phenomenon is analogous to the change of the form of the vibration of a rod when fixed by its middle or by its ends.

Quite similar is the mode of oscillation of a resonator 220 centimeters long disposed on one side of the vibrator; it possesses also a node at the middle not well defined, and a segment at each end.

To conclude, I will describe the mode of oscillation of a resonator 110 centimeters long, disposed parallel and symmetrically to the vibrator. This resonator possesses one node in the middle, very clearly defined, and a segment at either end. This form of oscillation is the same as would occur in the long resonator if one-fourth of its length from each end were cut off.

In the case of the latter resonator and of the long one, which is also symmetrically disposed to the vibrator, the oscillations are very stable, and much stronger than in the case of the resonators placed on one side of the vibrator. The mode of the oscillations of these symmetrical resonators is not disturbed by touching them by the fingers at any point, although the mode of oscillation is disturbed if we touch the unsymmetrical resonators at any point whatever.

The experiments described must be performed in a dark room, and much care be used in the choice of the proper Geissler tubes. Tubes containing mercury are very sensitive, and they become more so if the mercury be allowed to flow several times from one end of the tube to the other.

E. J. DRAGOUMIS.

Liverpool, March.

JACOBI, THE INVENTOR OF ELECTROTYPING.

THE subject of our sketch was a brother of Karl Gustav Jacobi, a German mathematician, and was born in Potsdam, Prussia, September 21, 1801. At the age of 28 he went to Russia to seek his fortune, and soon attracted attention by his researches in physics. In 1830 he constructed a short electric telegraph in St. Petersburg, and in 1832 one of eighteen miles between two of the imperial residences, on which he made many experiments and the important discovery that the earth could be used to complete the electric circuit. In 1837–38, about simultaneously with Thomas Spencer, of Liverpool, and Prof. Wagner, he invented the process of electrotyping. In 1840 he published *Die Galvanoplastik*, which gained him admittance into the Imperial Academy of St. Petersburg. In his investigations Jacobi was endeavoring to solve the problem of utilizing electro-magnetism as a motive power in place of steam, employing a Daniell battery. When the battery is working the sulphate of copper solution is slowly decomposed, depositing metallic copper, which, after a certain quantity of it has been accumulated, interferes with the action of the battery and must be removed. Once, while Jacobi was removing such a deposit, he noticed that there were several layers of copper, each having the form of the sides of his vessel. The fact that the disposition of these layers imitated, in a remarkably perfect manner, the shape of the surfaces of the vessels to which they adhered, suggested to Jacobi the idea that this troublesome phenomenon might be turned to profit by employing it for reproducing effects in metal. His discovery attracted at the time such attention that the Emperor Nicholas, after satisfying himself of its great value, gave its author the means of making the new art the common property of the world. He soon after proposed to the Czar the formation of a regiment of galvanic sappers, to be trained in the management of electric appliances. An immense battery was constructed for him, and he received the title of colonel in the galvanic regiment. He published many memoirs on the applications of electro-magnetism. He died at St. Petersburg, March 10, 1874.

JACOBI, THE INVENTOR OF ELECTROTYPING.

SULPHONAL.

THE *Brussels Medical Journal*, in an article by Dr. L. Stienon, gives the following *resume* of the results published during 1888 by *seventeen* medical authors who have written on this new therapeutic agent: Sulphonal was discovered by Baumann. It is diethylsulphonedimethyl-methane. *Character.*—Thick crystals, melting at 180 to 181° C., soluble in 15 parts of boiling water, in 135 parts of ether, and 65 parts of alcohol at 15°; rather soluble in benzole and chloroform, nearly insoluble in cold water. It is without odor and taste, sometimes slightly bitter. *Experiments on animals.*—Given at the dose of 2 grammes (30 grains English) to a dog, sulphonal produces in 30 to 45 minutes disordered movements and then sleep. At the dose of 78 milligrammes (a milligramme is one sixty-fifth grain English) for each kilogramme (2 lb.) weight of the animal, sulphonal produced in two guinea pigs a fall of temperature equal to 1·4° C. (2½° Fahr.) No action on the movements of the heart or on those of respiration. No influence on the digestive functions. *Effects on healthy men.*—2 to 3 grammes prolong (exaggerate) normal sleep. *Effects on patients.*—In the most varied pathological cases (neuroses, mental disease, senility, cerebral lesions, acute diseases, cardiac affections, etc.), sulphonal at the dose of 2 to 3 grammes (the gramme is about 15 grains English) produces in from half an hour to two or three hours a calm and deep sleep which lasts from five to eight hours. Next day no important after effects are observed. The patient on awakening experiences a feeling of well being. With agitated persons (general paralysis, morphinomania) the effects are less satisfactory. The day after high doses the head is affected, there is fatigue and vertigo. In one case sulphonal produced an exanthema similar to variola. *Indications.*—In nervous insomnia, especially in melancholia and morphinomania. *Counter-indications.*—The action is *nil* or next to *nil* in cases of great agitation, pain, cough, and disorded respiration. The use of sulphonal has given rise to accidents (repeated attacks of angina pectoris) in a man who was suffering from aterio sclerosis. *Mode of administration and doses.*—1 gramme (15 grains) will not with certainty produce any effect. 2 grammes (30 grains) are almost always effective. Some practitioners give 3 or 4 grammes, or even 5 grammes. The dose of 25 to 30 centigrammes (4 to 5 grains) is sufficient for children. The patient does not get accustomed to the drug. It is best given as a powder and the whole dose at once, followed by some warm drink, preferably by hot soup (bouillon), which causes it to dissolve.

ON FLAME.*

By F. J. ROWAN.

THE subject of flame possesses considerable interest from a technical point of view, because the questions connected with its nature and propagation enter into our understanding of several problems which are of first-rate importance to practical applications of science.

The nature of flame and the temperature which results from its existence bear directly upon our application of fuel and on the intensity of the heat which we produce by combustion. The velocity of ignition is a matter which in several ways is closely connected with the safe working of collieries; and recent research has shown us that the principles of gas engine practice embrace considerations alike of the nature, temperature, and propagation of flame.

In the following remarks the author aims merely at setting forth some of the general principles of the subject, without making any specific application of them to the important problems indicated.

Nature of Flame.—What is flame? Dr. Mills has remarked that a flame may be regarded as volatile matter undergoing chemical change at a visibly red heat; and Dr. Percy, with more minuteness, says:

"Ordinary flame is gas or vapor of which the *surface*, in contact with atmospheric air, is burning with the emission of light."

These definitions leave little to be desired, as they properly direct attention to *visibility* rather than to temperature, and to the fact that the presence of combustible *gas* or *vapor* is a necessary condition to the existence of flame. We may have a solid, such as iron, magnesium, or carbon,† burning in oxygen or air, at a high temperature, with brilliant incandescence, or glowing, but without flame, while, on the other hand, the flame of boric methide shows that flame may exist without a high temperature.

Flames are usually regarded as simple or compound, according to the number of products which result from them. Those which are ordinarily used in the arts and manufactures are compound flames.

From the foregoing definition of flame, it will be readily understood that all flames are more or less hollow in structure. In the center is a space occupied by unconsumed gases; surrounding that is the luminous portion of the flame; and outside of all is the non-luminous part, or "mantle," as it is called. The unconsumed inflammable gases can be collected from the center of the flame and afterward ignited, and the mantle can be rendered more visible (according to Bloxam‡) by burning sodium near the flame, when the mantle will acquire a strong yellow tinge.

In a blow-pipe flame, the same construction is observed, the flame, however, being diminished in size and luminosity; but by mixing air with gas before ignition, the three portions of a flame are reduced to two, with a considerable reduction in the luminosity of the flame. The combustion becomes complete at an earlier period, and the luminous cone has the same character as the mantle in the former case.

Temperature and Propagation of Flame.—Some interesting observations made by Deville§ on the flame of carbonic oxide burned with oxygen show the chemical composition of the gases at various parts of the flame. He found that when a mixture of carbonic oxide and oxygen in the combining proportions (2 vols. CO to 1 vol. O) was allowed to issue, under a slight pressure, from a jet having an area of 5 square mm., a flame of 70 to 100 mm. high was formed, consisting of an inner and an outer cone. The outer cone, in which combustion takes place, was deep blue at the base and yellowish or nearly colorless toward the apex. In the inner cone, which was only 10 mm. high, no combustion took place, because the rapidity of displacement of the particles of gas was there superior to the very slow rate of propagation of heat in the mixture.

To collect the gases from the different parts of the flame, a silver tube, pierced with a small aperture, was placed across it in the part to be examined, and the gases were aspirated by passing a rapid stream of water through the tube. They were thus quickly cooled, and, passing along the tube together with the water, were collected, by means of a bent delivery tube, in jars over water.

The following table gives the results of the various observations, the first column giving the positions of the silver tube above the orifice from which the gases issued, the second column the temperatures approximately at these points, and the last division of the table the composition of the gas at the different portions of the flame:

Height above Orifice.	Corresponding Temperatures.	Composition of the Gas.		
		CO.	O.	CO_2
Mm.				
67	Melting heat of silver, and above	0·2	21·3	78·5
54	Melting heat of gold	6·2	28·1	65·7
44	Commencing white heat of platinum	10·0	20·0	70·0
35	White heat of platinum	17·3	24·8	57·9
28	Strong white heat of platinum	19·4	26·5	54·1
18	Intense white heat of platinum	29 0	25·1	45·9
15	Incipient fusion of platinum	40·0	32·9	27·1
12	Melting point of platinum	47·0	36·0	17·0
(1) 10	Sparkling of the melted platinum	55·3	35·3	9·4
(2) 10	Still higher temperature	55·1	36·5	8 4
(3) 0		64·4	33·3	2·3

(1) A little above the apex of the inner cone.
(2) Somewhat below the apex of the inner cone.
(3) Original mixture.

These numbers show that the highest temperature is at the apex of the inner cone, or a little below it; that the temperature gradually diminishes toward the apex of the flame; and that the quantity of carbonic anhydride increases in the same proportion from the apex of the inner cone, where, at most, two-thirds of the carbonic oxide and oxygen enter into combination, to the vertex of the flame itself, where carbonic oxide can no longer be detected. At the apex and edges of the inner cone the carbonic oxide and oxygen unite almost instantaneously, but only partially, on account of the very high temperature there existing.* Bunsen also carefully investigated this subject, and introduced† some modifications of the views held previously. Watts (Dict. of Chem., i. 860, Affinity) has summarized this matter as follows: When a combustible gas mixed with oxygen is set on fire, a rise of temperature takes place, which, supposing the combustion to be perfect, may be calculated from the heat of combustion of the gases and the specific heat of the products. If, on the other hand, the combustion is imperfect, the temperature may still be calculated with the aid of Mariotte's and Gay-Lussac's laws, provided the pressure exerted by the gaseous mixture when exploded in a closed vessel be known. This pressure has been determined by Bunsen for mixtures of hydrogen and carbonic oxide with oxygen, or with oxygen and nitrogen together, by means of an eudiometer having a loaded safety valve. From this and the observed temperature of combustion, the quantity of the combustible gas (carbonic oxide or hydrogen) which has been burned at the moment when the flame attains its maximum temperature, and thence also the quantity which at this temperature has lost its power of combining, may be calculated.

The following table contains the results of Bunsen's experiments arranged according to the maxima of temperature (t^1—t) which the several gaseous mixtures, calculated for volumes at 0° C., attain by combustion in a closed vessel. Columns I. and II. give the mixtures of gases used; $\frac{P}{P_o}$ = the pressure produced in atmospheres by explosion; t = the calculated temperatures; and k = the calculated proportion of combination.

No.	Mixtures of Gases. I.	with II.	$\frac{P}{P_o}$ III.	t. IV.	k. V.	Mean.	Deviation from Mean.
1	⅔ vol. CO	+⅓ vol. O	10·78	3,172	0·351	0·3316	+0·0194
2	" CO	+ " O	11·19	2,893	0·319		—0·0136
3	" H	+ " O	9·97	2,854	0·338		+0 0064
4	" H	+ " O	9·75	2,833	0·336		+0·0044
5	" CO	+ 0+0·1079 vol. O	9·05	2,558	0·314		—0·0176
6	" CO	+ 0+0·6857 " CO	8·89	2,471	0·469		—0·0421
7	" CO	+ 0+0·8854 " O	8·44	2,835	0·478		—0·0241
8	" CO	+ 0+1·0861 " O	7·86	2,117	0·490		—0·0121
9	" CO	+ 0+1·2563 " N	7·73	2,084	0·515		+0·0129
10	" H	+ 0+1·2599 " N	7·49	2,034	0·547	0·5021	+0·0449
11	" CO	+ 0+1·2563 " N	7·35	1,909	0·470		—0·0321
12	" CO	+ 0+1·7145 " O	6·67	1,726	0·530		+0·0179
13	" CO	+ 0+2·1559 vols. O	5·83	1,460	0·512		+0 0099
14	" CO	+ 0+3·1629 " CO	4·79	1,146	0·547		+0·0949

These numbers, in Bunsen's view, show that, in a mixture of carbonic oxide or hydrogen with the exact proportion of oxygen required for combustion, and unmixed with any diluent gas, only one-third of the carbonic oxide or hydrogen is burned at the maximum temperature, while the other two-thirds, by being raised to the high temperatures of 2,558° to 3,033°, have lost the power of combining; moreover, that, when one volume of the same mixture is diluted with 0·686 to 3·163 volumes of any gas that does not burn with it, and the temperature of the flame is successively reduced thereby from 2,471° to 1,146°, then, at all temperatures within these, exactly half of the carbonic oxide or hydrogen is burned, the other half having lost the power of combining.

From this it has been inferred that the combustion of gases takes place in a manner different from that which had been previously supposed. When a mixture of two volumes of carbonic oxide with one volume of oxygen is set on fire, and its temperature thereby raised from 0° to 3,033° C., two-thirds of the carbonic oxide remains in an unburned and, for the time, incombustible state. The temperature is then lowered by radiation and conduction from 3,033° to 2,558° without any combustion of the carbonic oxide, but when the temperature falls somewhat lower, combustion recommences, restoring the heat lost by radiation and conduction, and raising the temperature again to 2,558°, but not above that point. The gradual fall of temperature from 3,033° is followed by a continuance of the temperature 2,558° till exactly half the carbonic oxide is burned, whereupon a third phase sets in, during which, again, no combustion takes place until the inflamed gaseous mixture has cooled down to at least 1,146°. As, however, the gaseous mixture, after cooling, consists almost wholly of carbonic anhydride, these alternate phases of constant and decreasing temperature must be repeated below 1,146° until the last portion of the gas is burned. This discontinuous combustion of a uniform mixture of a combustible gas with oxygen is referred by Bunsen to a law of combination established by him.

These facts, as observed by Bunsen, are of great importance in connection with the inflammation of gases, although it is probable, as Berthelot has indicated, that Bunsen's temperatures are too high in consequence of his not having considered the contraction of volume due to combination.

Berthelot* announced that the combustion temperatures in Bunsen's experiments may be anything between the limits shown in the following numbers, keeping the same numerical order as in the foregoing table:

No.	t^1.	t^2.	No.	t^1.	t^2.
	°	°		°	°
1	4,140	2,612	8	2,280	1,875
2	3,900	2,537	9	2,203	1,838
3	3,809	2,449	10	2,126	1.715
4	3,718	2,389	11	2,083	1,734
5	3,066	2,198	12	1,875	1,548
6	2,760	2,154	13	1,505	1,319
7	2,537	2,031	14	1,150	1,064

A number of experiments on this subject have been made since Berthelot's criticism appeared, but the conclusions arrived at are contradictory. All, however, agree in observing a great absorption of heat at high temperatures, which is thought to be due either to a change in the specific heat of gases or to dissociation. Messrs. Berthelot and Vieille† and Mallard and Le Chatelier‡ have advanced and supported the former view, while the latter has been advocated by Mr. Dugald Clerk§ and Professor Rucker, of Leeds. It is probable that both causes operate to produce the phenomena which have been observed.

The rate of ignition of gaseous mixtures is also a point of considerable importance. Sir H. Davy‖ propounded a theory of this action, but it does not seem to be entirely supported by more recent investigations.

Bunsen found that the velocity of the propagation of combustion in a pure detonating mixture of hydrogen and oxygen was 34 meters per second, and in a maximum explosive mixture of carbonic oxide and oxygen it was less than one meter per second. When the explosive gases are gradually diluted with a gas that does not take part in the combustion, the rate is lowered, and it can be brought down thus until the progress of combustion is made visible to the eye.

Bunsen's method of determining these velocities is thus described by Dugald Clerk (*loc. cit.*): The explosive mixture was allowed to burn from a fine orifice of known diameter, and the rate of the current of the gaseous mixture was carefully regulated by diminishing the pressure to the point at which flame passed back through the orifice and ignited the gases below it. This passing back of the flame occurs when the velocity with which the gaseous mixture issues from the orifice is inappreciably less than the velocity with which the inflammation of the upper layers of burning gas is propagated to the lower and unignited layers.

Professor Mallard,¶ of the Ecole des Mines, made a series of observations by this method on the rate of the propagation of combustion in mixtures of coal gas and air and of marsh gas and air. In the latter mixtures, the maximum rapidity of inflammation was found to be about 0·56 meter, or rather more than half a yard, per second. This velocity was attained with a mixture of 1 vol. marsh gas and 8½ vols. air. When the proportion of air was increased to 12 vols. or diminished to 5·9 vols., the mixture was neither explosive nor inflammable.** Professor Thorpe remarks on this that it is worthy of note that the proportion of air corresponding with the maximum rate of inflammation is less than that which contains oxygen sufficient for the complete combustion of the marsh gas. This, however, is what the observations by Bunsen and others, previously quoted, would lead us to expect.

The maximum rapidity of inflammation in mixtures

---

* A paper read before the Society of Chemical Industry, Glasgow, March 5, 1889. From the *Journal* of the Society.

† This is true of single pieces of carbon—a mass of carbon burning in air or oxygen generally shows a lambent blue flame on the surface, which is due to the burning of carbonic oxide, CO, formed by the reduction of the carbonic anhydride, CO_2, in its passage through the glowing carbon.

‡ "Chemistry," edition 1867, p. 95.

§ "Bull. Soc. Chim." [2], v. iii.; also Watts, "Dict. of Chemistry."

* See also Thorpe on the Theory of the Bunsen Lamp, "Jour. Chem. Soc.," 1877, i., p. 627, for Blochmann's investigations, or "Annalen Chem. Pharm.," vol. clxviii., p. 295.

† "Phil. Mag.," vol. xxxiv., p. 489, and "Gasometry," by R. Bunsen.

* "Ann. de Chim. et Phys." [5], vol. xii., pp. 302–310; "J. Chem. Soc.," vol. xxxiv., p. 5; "Compt. Rend.," vol. lxxxiv. (1887), p. 407.

† "Essai de Mecanique Chimique," Paris, 1879; "Ann. de Chim. et de Phys.," 5me ser., xxvii and xxviii.; 6me ser., iv., pp. 13-84.

‡ "Compt. Rend.," 1880, 1881, vols. xci., xciii.; "Annales des Mines," 8me ser., "Memoires," iv., p. 274.

§ On the Theory of the Gas Engine, "Min. Proc. Inst. C. E.," vol. lxix., part iii., also *ibid.*, vol. lxxxv., pp. 1-53. See also Rossetti, "On the Temperatures of Flames," "J. Chem. Soc.," vol. xxxiv., pp. 467, 694, etc.

‖ "Researches on Flame." See also Watts, Dict. of Chem., Combustion, i., 1089.

¶ "Annales des Mines," vol. viii., 1875, p. 355. Thorpe, on the "Theory of the Bunsen Lamp," "J. Chem. Soc.," 1877, i., p. 631.

** See also Coquillion's results in "J. Chem. Soc.," 1877, i., p. 166, and in "Compt. Rend.," 1876, vol. xxxiii., p. 709.

of coal gas and air was attained with a mixture of 5 vols. of air and 1 vol. of coal gas, and was 1·02 meter, or rather more than 1 yard, per second. One volume of coal gas with 6½ vols. of air gave a rate of 0·285 meter, or 11 inches, per second. The rate was very rapidly diminished by an excess of either constituent; a mixture containing more than 8 vols. and less than 3½ vols. of air to 1 of coal gas was found to be uninflammable in the way described.*

Dugald Clerk has pointed out that these are the rates of ignition at constant pressure, and that in a closed space the conditions of inflammation are quite different in consequence of the expansion of the ignited portion and mechanical disturbance of the remaining part of the gaseous mixture. Experiments are needed to determine the rate of ignition for constant volume. Some remarkable results are given by this author, which were obtained by so arranging the plan of ignition that a small volume of gases was first ignited, which expanded and projected a flame through a passage into the mass of an inflammable mixture, thus adding to the rate of ignition the mechanical disturbance produced by the entering flame. He succeeded by this means in producing maximum pressure (or maximum ignition) in $\frac{1}{75}$ part of a second in a space containing 200 cubic inches of gas. By firing a mixture with varying amounts of mechanical disturbance, almost any time of ignition could be obtained between $\frac{1}{10}$ and $\frac{1}{75}$ of a second. It did not matter whether the mixture used was rich or weak in gas; the rich mixture could be fired slowly, and the weak one rapidly, just as was required. He found that the rate of ignition of the strongest possible mixture is so slow that the time of attaining complete inflammation depends on the amount of mechanical disturbance permitted.

Mr. Lewis T. Wright has recorded, some interesting observations on the velocity of the propagation of flame, and has announced that, when flame travels at a greater velocity than 4¼ feet per second, it will pass through the gauze used in safety lamps. He also found that a flame of low velocity in a confined space may become so much agitated by an increase in its own oscillations as to cause the introduction of a very rapid rate of ignition in the remaining portions of the gaseous mixture. He remarks that "a definite explosive mixture may have a velocity of propagation of flame, when it is undergoing explosion of the first order, as low as 1½ feet per second; but when it becomes sufficiently agitated to give an explosion of the second order, the rate of propagation of flame is several thousand feet per second."

The following table shows the results of experiments with various mixtures of gases, giving the rate at which an explosion of the first order (that is, a slow ignition) travels with each mixture in a glass tube 13 feet long and 0·75 inch diameter:

Mixtures.		Lineal Velocity of Efflux of Mixture.	Rate at which Explosion of First Order Travels in Tube.	Total Velocity of Propagation of Flame.
Gas.	Air.	Feet Per Second.	Feet per Second.	Feet per Second.
Per cent.	Per cent.			
10·3	89·7	1·21	1·1	2·31
12·2	87·8	1·24	2·0	3·24
15·0	85·0	1·28	3·0	4·28
17·7	82·3	1·33	4·8	6·12
19·6	80·4	1·35	3·0	4·35
21·2	78·8	1·38	2·4	3·78
22·1	77·9	1·39	1·3	2·69
23·0	77·0	1·41	Stationary.	....

Wright also found that whenever an explosion is produced inside a safety lamp having ordinary gauze, the flame was projected through the gauze, and could ignite gas at a considerable distance from the lamp. By employing stiff wires for the woof and lighter wires for the warp, he produced a "basket work" gauze having small, tortuous openings and a relatively large weight of metal, which did not allow flame from an explosion to pass through.

Luminosity of Flames.—According to the commonly received theory of the causes of luminosity in flames (first propounded by Sir H. Davy†), the presence of solid particles suspended in the flame (or in immediate contact with the burning gas) is essential to its luminosity.

There is no doubt that the introduction of solid particles in a fine state of division into a flame of feeble luminosity will impart to it a considerable degree of brilliancy by the incandescence of the solid particles, or perhaps in some cases by reflection of the light from their many surfaces. No sound conclusion, however, as to the luminosity of flames in general can be drawn from such an analogy as is afforded by the result of such an experiment, because Tyndall has shown that the same result is produced when the solid introduced is one that does not burn. The presence of solid particles, according to the common idea, in luminous flames is only assumed, not proved. It is usual, however, to refer to the black deposit which is formed upon a glass rod or similar body, when it is held in the flame of a candle or of hydrocarbon gas, as a proof that such flames contain solid particles. This, however, is not a conclusive proof, for Dr. Franklands§ has pointed out that this deposit is not pure carbon, but is a hydrocarbon compound. To this Dr. Percy‖ objects that it is fixed, not volatile, whatever its composition may be; but the objection seems to be irrelevant, because it refers to the substance as deposited, and we do not know that such a substance existed in the flame. The introduction of the cold surface of the glass rod not only condenses some vaporous hydrocarbon, but doubtless also causes decomposition of some of the many hydrocarbons which make their appearance in the gradual resolution of carbonaceous matter. As, therefore, we do not know in what combination this substance producing the black deposit existed while it was originally in the burning gas, it cannot properly be asserted that it was "fixed, not volatile."

The phenomena of many luminous flames are explained by various writers, with more or less ingenuity, on the hypothesis of solid particles, but the experiments and observations of Dr. Frankland* have shown that that hypothesis is not wholly satisfactory, because luminous effects have been produced where it could not account for them, such, for example, as the luminosity of the flame of hydrogen burning in oxygen under pressure; and secondly, because in many of the brightest flames the temperature is such that fuliginous matter† could not exist in them. In many cases, it might seem, therefore, to be a more satisfactory explanation, that the luminosity of flames depends on the existence of a comparatively high temperature and on the presence of gases or vapors of considerable density.‡

Soret§ made, in 1874, some experiments which were intended to refute the opinion previously given by Hirn adverse to Davy's theory of solid particles. These experiments consisted in projecting, by means of lenses, the image of the sun on to the surface of several hydrocarbon flames, and examining the degree of polarization of the reflected light by the use of a Nicol's prism. As the light was observed by the eye, it was necessary to interpose several plates of cobalt-colored glass, and the sunlight was distinguishable from the light of the flame merely by means of a trace of blue which was ascribed to it as distinct from the purple color yielded by the flame light.

Soret obtained similar results, though in varying degree, with sunlight when reflected from lampblack, from non-incandescent smoke, from smoky carbon flames, and from the flames of candles and hydrocarbon gas having different degrees of carburation. When, however, the flame, even of highly carbureted gas, burned in an atmosphere of abundant oxygen, the blue trace and polarization effect were invisible. In fact, his best results were obtained in proportion to the decrease of luminosity. On this account Soret was not warranted in concluding, as he did, that his results support Davy's theory, because they failed just when it was important that they should not fail, namely, when the luminosity of the flames was largely increased. If we accept these experiments as showing that sunlight was reflected from finely divided particles in these flames, they also indicate that the *luminosity* of these flames was not only *not due* to the presence of these solid particles, but that, on the contrary, it was *diminished* by them, as they disappeared from the brighter flame.

More recently Burch‖ has to some extent repeated Soret's experiments, making use, however, of the spectroscope in the examination of the light from the flame, and thus being better able to distinguish between it and the reflected sunlight. He found that the reflected sunlight showed all the Fraunhofer lines, and that, on using the Nicol's prism, it was polarized at right angles to the line of incidence; and he compared this result with that obtained from the reflection from finely divided particles of shellac as precipitated by and suspended in water.

The observed effects being the same, he was perhaps justified in concluding that in the flames which he examined, the sunlight was reflected from finely divided solid particles; although in the present state of this branch of the science of optics, it would be foolish to consider this matter *proved*. Finely divided solid matter suspended in a viscous fluid, and rushing through a flame, represent very different physical conditions, and it is extremely improbable that we can safely reason from results afforded by one phenomenon to those of the other. The flame itself, by reason of the intense vibrations which constitute its existence, may behave toward sunlight in a manner very different from that of a transparent and almost quiescent liquid.

At any rate, Burch's results are far from proving that the *luminosity* of these flames was in any way dependent upon the presence of solid particles, except in so far (as Soret's experiments teach) as they may have acted in diminishing the degree of luminosity. The mere fact of the *presence* of solid particles, supposing that to be established, does not prove anything regarding any relation between them and luminosity. This is a distinct subject for proof.

On the other hand, the effect of high temperature is seen in the greater brightness of the flames of sulphur, phosphorus, and, indeed, all substances when burnt in pure oxygen, as compared with the result of their combustion in air. Direct evidence of the effect of high temperature is also afforded by the combustion of phosphorus in chlorine, for while at ordinary temperatures only a feeble light is produced by this combustion (although the product PCl_5 has considerable density), strongly heated phosphorus vapor burns in hot chlorine with a dazzling white light.

A comparison of the relative densities of gases and vapors shows that the brightest flames in general are those which contain the densest vapors.

Relative Densities of some Gases and Vapors.

Hydrogen	1
Water	9
Hydrochloric acid	18½
Arsenious chloride	93¾
Metallic arsenic	150
Arsenious oxide	198
Air	14·5
Oxygen	16
Carbon dioxide	22
Sulphur dioxide	32
Phosphoric oxide	71 or 142
Chlorine	35·5
Mercury	200

Hydrogen burning in chlorine produces a vapor more than twice as heavy as that resulting from its combustion in oxygen, and accordingly the light produced in the former case is stronger than in the latter. Carbon and sulphur burning in oxygen produce vapors of still greater denstiy (viz., CO_2 and SO_2), and their combustion gives a still brighter light. Phosphorus, also, which has a very dense vapor, and yields, in burning, a product of great vapor density, burns in oxygen with a brilliancy almost blinding.

The luminosity of a flame is increased by compressing around it the surrounding gaseous atmosphere, and it is diminished by rarefying it. Thus, mixtures of hydrogen and carbonic oxide with oxygen emit but little light when they are burnt or exploded in free air, but exhibit intense luminosity when exploded in closed vessels so as to prevent expansion of the gases at the moment of combustion.

Frankland experimented with jets of hydrogen and carbonic oxide burning in oxygen under a pressure which he gradually increased to twenty atmospheres, and obtained brilliant luminous effects, including bright and continuous spectra. Even the faint flame of alcohol, as in an ordinary spirit lamp, becomes highly luminous under the receiver of a condensing pump, when the pressure of air is increased to 120 inches of mercury.

We are indebted to Frankland* also for the observation that the diminution in illuminating power is directly proportional to the diminution in pressure; and, as applied to ordinary domestic gas burners, this means that, as the barometer falls, the light from them diminishes at the rate of 5·1 per cent. for every inch of fall. According to Dr. Letheby, † "in London the difference in the value of the light when the barometer is 31, as compared with what it is at 28, is fully 25 per cent."

The flame of arsenic burning in oxygen may also be rendered quite feeble by rarefying the oxygen; and, at high altitudes, flames exhibit the effects of rarefied air. Tyndall and Frankland‡ made observations on the combustion of stearin candles at the summit of Mont Blanc and at Chamouni, and found a considerable decrease in luminosity at the high elevation, although the rate of combustion of the candles remained the same in both places. The energy of combustion was therefore unaltered, although the flame in one case had a higher temperature than in the other, resulting from the increased density of the gaseous atmosphere. Percy shows (vol. "Fuel," p. 159) that this conclusion should be drawn even from the theory propounded by Tyndall in explanation of the diminished luminosity which he observed on Mont Blanc. Tyndall's theory was that the decrease in luminosity was mainly due to the greater mobility of the air. From this Percy reasons, "Now, if increased mobility of the air be caused by rarefaction, the opposite should result from compression, in which case the movement of the particles would become sluggish, intermixture of the air and flame producing gas would be less rapid, and the diffusion of the gaseous products of combustion in the surrounding air would be retarded, with consequent increase of temperature."

Frankland's conclusions have also been confirmed by some experiments by Professor V. Wartha § on the influence of pressure on flames.

[FROM INSECT LIFE.]

THE HABITS OF THALESSA AND TREMEX.‖

By C. V. RILEY.

STRUCTURE OF THE OVIPOSITOR.

OUR readers who have followed us so far will doubtless wonder how an egg can be passed down such a long ovipositor not wider than a horse-hair. A careful examination will show that this instrument is composed of three parts, which may, upon being softened, easily separate, but which in nature are securely locked together. Fig. 3 illustrates the ends of these three

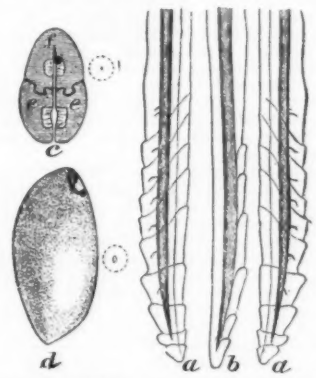


FIG. 3.—OVIPOSITOR AND EGG OF THALESSA.

a, *b*, *a*, tips of component parts of ovipositor proper; *c*, cross section of ovipositor; *d*, egg; *e*, *e*, ventral pieces of ovipositor proper; *f*, middle or dorsal piece of ovipositor, all greatly enlarged (original).

parts, *a*, *a*, *b*, as they appear when on their flat sides, and it will be noticed that the tips are strongly notched diagonally, which structure facilitates the insertion or boring into the tree and renders extraction somewhat more difficult, especially where the wood is somewhat hard. Now the dorsal or central piece is solid at its dorsal end and cleft on the inner side to about two-thirds or three-fourths its length. On either side of this cleft is a strong ridge or rail something after the fashion of a T-rail. Each of the ventral pieces, on the contrary, has a groove into which the rail-like ridges of the dorsal piece lock. The ventral pieces in the act of oviposition slide up and down these rails, which

---

* "Compt. Rend.," vol. xcv., pp. 151-157; "Ann. de Chim. et Phys." [6], vol. vi., 1885, pp. 546, 556.

† "J. Soc. Chem. Ind.," vol. vi., pp. 362-364.

‡ "Phil. Trans." for 1817, p. 75.

§ "Proc. Roy. Soc.," Lond., vol. xvi., 1868; "Phil. Mag.," vol. xxxvi., 1868, pp. 309-311; "Experimental Researches;" "Lectures on Coal Gas."

‖ "Metallurgy," vol. "Fuel," p. 158.

* *Op. cit.* and "J. Chem. Soc.," Lond., 1864, vol. xvii., pp. 52-55; "Brit. Assoc. Reports," vol. xxxviii., p. 37; "Proc. Roy. Inst.," vol. v., 1869, pp. 419-423; "Proc. Roy. Soc.," Lond., vol. xxx., No. 201.

† See Lectures on Coal Gas, delivered at the Royal Institution, London, March, 1867, by Dr. Frankland, published in the "Jour. of Gas Lighting," etc., London.

‡ "Jour. Soc. Chem.," 1862, vol. xv., p. 168; Watts, "Dict. of Chemistry," 1st sup., p. 485.

§ "Phil. Mag." ser. 4, vol. xlvii., p. 205; vol. 1875, p. 50. Translated from "Archives des Sciences" of the "Bibliotheque Universelle," 1873 and 1874.

‖ "Nature," vol. xxxi., p. 272.

* *Op. cit.* and "Phil. Trans.," vol. cli., 1861, p. 629.

† "Common Sense for Gas Users," by R. Wilson, p. 19 (London: Crosby, Lockwood & Co.)

‡ "Heat considered as a Mode of Motion," by J. Tyndall, F.R.S., 1865, p. 50.

§ "Jour. fur Gasbeleuchtung," vol. xix., p. 761; "Min. Proc. Inst. C.E.," vol. xlviii., part ii., p. 329.

‖ Continued from SUPPLEMENT, No. 700, page 11188.

serve to keep the three pieces securely fastened together. Through the center of the dorsal piece runs a membranous duct, which is probably muscular, and is formed by a groove on either side of the cleft, while through the connected piece that the other or ventral pieces make when conjoined runs another similar duct. The margins of the membrane in either duct when seen by cross section look somewhat like a septum. Fig. 3, *c*, shows a cross section of the three pieces when interlocked, taken about the middle of the ovipositor, the appearance varying somewhat in different parts of the instrument. The egg (Fig. 3, *d*) is 0·18 mm. long and 0·13 mm. in greatest width. It is ovoid in form, and compressed at the sides, and is evidently worked down by the muscular linings of these grooves. The pieces as a whole are, when interlocked, doubtless bulged out to admit of the passage of this egg. The greatest expansion must take place about the middle of the cleft by virtue of the fact that while the combined ovipositor is oval in transverse section the burrow or perforation is more cylindrical, thus permitting the bulging of the cleft at its middle and preventing too great separation of the open end formed by the ventral pieces.

We are much indebted to Mr. Gade for specimens of the egg, as also for preserved females showing the distended membrane. The dimensions of the egg which we have given are from eggs examined by dissection in the female abdomen, and correspond to the size of the ovipositor, but the eggs from Mr. Gade, and from which our figure was made, are larger and more elongate.

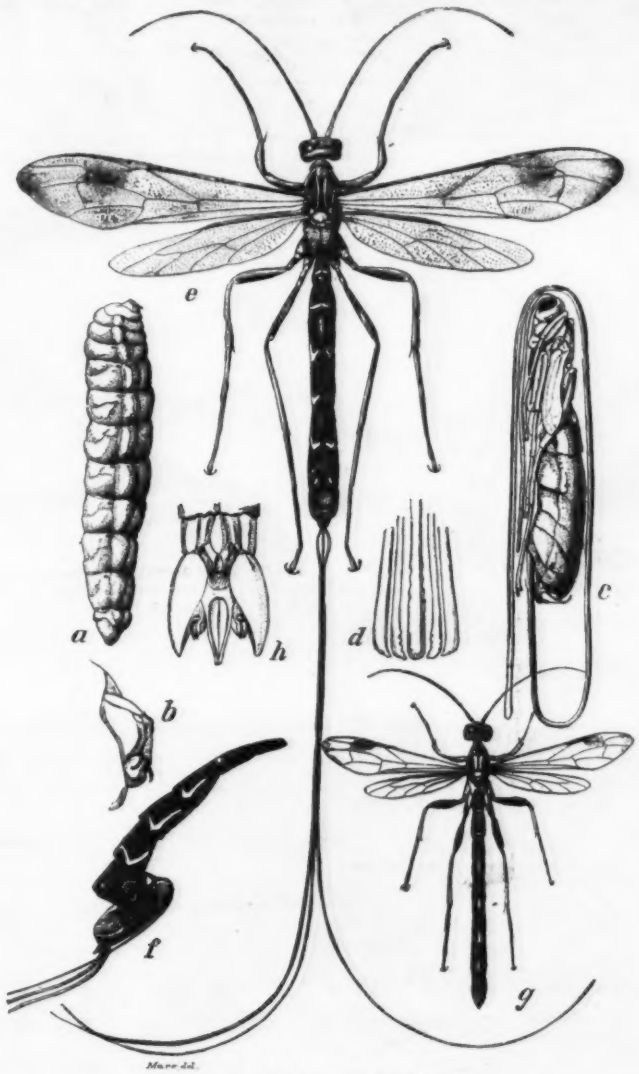


FIG. 4.—THALESSA LUNATOR.

a, larva, side view; *b*, head of larva from side; *c*, pupa, side view; *d*, tip of ovipositor of pupa, ventral view greatly enlarged to show five parts (including sheaths) of which it consists; *e*, adult female; *f*, abdomen of adult female from side, showing gap between joints 6 and 7, from which the membrane distends when ovipositor is in action; *g*, adult male; *h*, anal extremity of abdomen of male enlarged (original).

The manner in which the females, especially after they have been enfeebled, become fast in the trunks which they bore has often been recorded as a matter of observation. On November 9, 1872, at Glencoe, Mo., we found the nearly mature female Thalessa in another box elder tree, already mature, but dormant, but evidently ready to issue early the following summer, because she had eaten right to the surface of the bark. The Tremex larvæ were at this time of all sizes, and a careful examination of this tree showed the vicissitudes to which these insects are subject, not only after, but before, exit; for females of both genera were often found dead in the tree. The Thalessa matures within its burrow with the wings perfect, and as it depends very largely on the use of its matured jaws for escape, it frequently fails to escape when encountering gnarled and knotty wood.

The Tremex, both in the larva and pupa states, is quite subject to the attacks of a fungus which so closely resembles the dying and decaying parts of the wood that the infected parts of the skin seemed filled with dead wood.

ARDOR OF THE MALES.

The ardor of the males of Thalessa has often been commented upon.

Mr. W. H. Harrington, in the *Canadian Entomologist* for November, 1887 (Vol. XIX., p. 206), recounts, under the head "The Nuptials of Thalessa," a series of interesting observations made in June, 1887, and which showed that the males, having issued first, awaited the females, and were able to locate the spot at which a given female would emerge some time before she made her appearance. In one instance which he records, a particular spot was crowded with males for two days before the female emerged, and even then she was assisted by the removal of the bark by the observer. The males, in waiting, make every effort to reach the female, inserting the tips of their abdomen into crevices in the bark. On emerging the female is instantly seized, the legs of the male clasping the yet unused wings and abdomen, thus preventing her from flying.

DOES THE FEMALE OVIPOSIT IN EXPOSED LEPIDOPTEROUS LARVÆ?

In a communication to the *Country Gentleman* of July 12, 1883, page 561, Prof. J. A. Lintner raised the question as to whether this insect was really constructed for preying as a parasite upon internal borers or whether it did not prey upon exposed larvæ. He wrote as follows:

"The question is therefore raised, Are the commonly accepted habits of the 'long-stings' correctly given? Has any one actually seen them in the act of probing the burrows of a *Tremex*? Such an operation has never come under my observation, while probably all field entomologists have repeatedly found them fastened by their ovipositor firmly inserted in apparently solid wood. I recall an instance observed by me several years ago, when what I think must have been *Rhyssa lunator* was earnestly engaged in placing its eggs in a colony of a species of *Datana*, feeding upon a branch of hickory, in the following singular manner: Its ovipositor was bent beneath it, extending between its legs, with its tip projecting in front of its head, enabling it with perfect ease to select one caterpillar after another for the reception of its eggs. Why would not this be a much better method of using the long ovipositor than the one generally ascribed to it? There would certainly be no haphazard work in such oviposition, or any waste of material. In the instance above recorded each thrust told, as was seen in the well known alarm jerk of these larvæ, at once communicated from the victim to the entire group. Unfortunately the importance of the observation was not known to me at the time, and no further attention was given to it."

Quite recently, desiring to learn whether Professor Lintner had obtained any further evidence to justify so singular a statement, we addressed him, and he informed us that he had no further experience other than that given in his forthcoming report, of which he kindly sent us advance proofs, and in which he quotes a similar observation narrated by Mr. J. S. Woodward, secretary of the New York State Agricultural Society, after repeating his own experience as we have quoted it. The trouble is that in both Mr. Lintner's and Mr. Woodward's observations memory is the sole guide, and there has been no positive identification of the species, and, though we have a high regard for the observational powers of both these gentlemen, it seems to us that both must be in error, because a study of the structure of the ovipositor in Thalessa shows clearly that it is not adapted for stinging soft-bodied larvæ. The very curious structural peculiarities of the abdomen, which we have just described, and which are essential to permit the tip of the ovipositor to be projected against the trunk of the tree, are also inconsistent with the motions described by Professor Lintner. So, also, the labored force necessary to bring the ovipositor in position, and in the general act of oviposition in Thalessa, does not agree with what is there described. While the relative length of ovipositor to body varies somewhat, the former generally extends about five inches from the tip of the latter, and if brought under the body would extend over three inches beyond the head. Moreover, there is no sharp lance at tip, nor means of curving this last so as to bring it on the back of a caterpillar with the ichneumon in the position described by Lintner.

The ovipositor of Thalessa is, in short, an elaborate boring and sawing instrument. The simplest explanation of both Lintner's and Woodward's observations would be that, if the insect was Thalessa, she was by chance boring a branch or trunk infested with Tremex at a place where Datana larvæ were massing, as they are known to congregate for moulting purposes in masses upon the trunk. But, as will be seen, Professor Lintner's statement is too explicit as to the alarm jerk of the stung Datana larvæ to justify this first explanation of the riddle, and the attitude assumed by Thalessa would not correspond to his description; so that upon careful consideration we are satisfied that the true explanation is that some other large Ichneumonid was observed by both and by both mistaken for Thalessa. Some of the large ophionids of the genera Thyreodon, Exochilum, or Heteropelma might be quite easily mistaken, therefore, especially at some little distance.

Both Exochilum and Heteropelma are parasitic upon Bombycid larvæ, which feed externally like Datana, and in our breeding experience we have found the commonest parasite of *Datana ministra* and *Datana integerrima* to be a large undescribed Heteropelma that might easily be confounded with *Thalessa lunator*, unless one is quite careful in observation. It is true that the ovipositor in these genera cannot be extended to any great length, probably not more than half an inch; but the abdomen in oviposition is undoubtedly

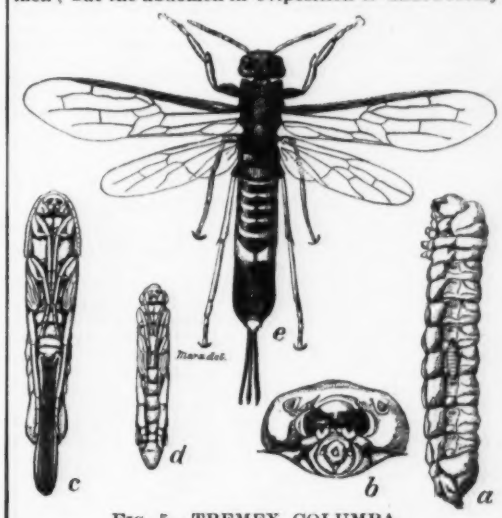


FIG. 5.—TREMEX COLUMBA.

a, larva, showing Thalessa larva attached to its side; *b*, head of larva, front view, enlarged; *c*, female pupa, ventral view; *d*, male pupa, ventral view; *e*, adult female—all slightly enlarged (original).

curved under the body in such way that the caterpillars are stung in front of the parasite very much as described by Mr. Lintner. The abdomen is long enough to allow this, and it is the customary position with Ophionids when ovipositing. Another black species (*H. flavicornis*) resembles, in a similar way, *Thalessa atrata*.

The particular species of Heteropelma which we have bred from Datana larva is undescribed, and at Mr. Cresson's request we add a description of it in this connection:

"*Heteropelma datanæ* sp. nov.

"*Female.*—Average length 25 mm.; expanse 35 mm. General color ferruginous brown, the abdomen verging to bronzy black. *Head:* Antennæ uniform yellowish brown, a little darker than head and thorax, the scape yellowish below; face below antennæ, and a narrow band around eyes (sometimes obsolete above) gamboge yellow; eyes black or dark brown. *Thorax* darker above than below; mesoscutum with three broad, indistinct, darker longitudinal bands, which vary considerably in intensity, rather sparsely punctate, slightly shining, with a very faint median longitudinal sulcus. Mesoscutellum usually rather lighter in color than scutum, more densely punctate, opaque. Metanotum varying considerably in intensity of color, very rugose, the irregular carinæ which produce the rugosity much darker than the intervening spaces, a very shallow median longitudinal groove. Legs, especially tibiæ and tarsi, lighter in color than thorax. Front trochanters sometimes quite yellow; first joint of hind tarsi fully five times as long as second joint. Wings uniformly dark fuliginous, with a bronze reflection; tegulæ concolorous with rest of mesoscutum. *Abdomen* with petiole, concolorous with thorax; joint 2 with a black stripe above, reddish brown below. Joints 3 to 7 dusky, nearly black, with a bronzy or purplish sheen, lighter on ventral line. Outer sheaths of ovipositor lanceolate, black except at immediate base and strongly pilose.

"Eight ♀ specimens from pupæ of *Datana integerrima*.

"Differs at a glance from the only other North American species of the genus, viz.: *H. flavicornis* Brulle and *H. longipes* Provancher."

In reference to the transformations of Thalessa our figures will sufficiently illustrate them, so that there is not much need of a further remark. The larva (Fig. 4,

a), as will be seen, has the ordinary Ichneumonid form, tapering at both ends, and has the typical parasitic jaws, *b*, quite incapable of gnawing through wood. The spiracles are normally arranged. The most interesting feature of the adolescent stages is the pupa, in which the long ovipositor extends at first in a direct line from the point of insertion and then bends in a loop and is brought back over the dorsum and around the head and then back again on the ventral side, hugging the legs, its tip reaching far beyond the tip of the abdomen. In this it differs from the European *Rhyssa persuasoria*, in which the ovipositor of the pupa, according to Snellen's figures, previously mentioned, reaches only some two-thirds the length of the body behind the back.

It remains only to state in reference to the habits and transformations of Tremex (see Fig. 5) that, from the facts already mentioned, it would seem that the imagoes mature, as a rule, somewhat later than Thalessa, and that the larvæ are found of various sizes on the approach of winter. We have also found, on one occasion, at Emporia, Kans., on December 16, 1874, in *Celtis occidentalis*, a Tremex imago somewhat torpid and eaten half way out of the trunk. There are no positive records in this country to show the length of duration of the larva state in either of these genera, but we should expect the Thalessa larva to develop most rapidly when once it finds its food, but to possess also great power of enduring without food in early life. There is doubtless much irregularity in development in both genera, especially after the pupa state is assumed, while the period of oviposition, as we know, may cover several of the summer months.

The larva (Fig. 5, *a*) has the normal form of the horn tails, being blunter at both ends than the Thalessa, with an anal thorn, short thoracic legs and strong gnawing jaws (Fig. 5, *b*). Our figure (*a*) shows a young Thalessa larva attached about the middle, just as it has remained since 1872 in our alcoholic specimens. The ovipositor in the female pupa, as shown in the figure (*c*), is not bent.

We have the authority of Kollar that the larva of *Sirex gigas* attains full growth in seven weeks after the laying of the egg, and that in the pupa state it may remain in the tree for several years. Normally both Thalessa and Tremex probably go through their transformations within a year. *Tremex columba* is at times abundant enough to materially injure trees, and Mr. Jonathan Periam, the present editor of the *Prairie Farmer*, sent us an account (November 28, 1873) of a hickory tree which he believed was killed by it. Our figures will convey a very good idea of the adolescent states of both. They were drawn by Dr. Marx, with our assistance, from our Missouri material, and also from a pupa kindly loaned for the purpose by Dr. H. A. Hagen, our own examples of the pupa being too mature to permit of a good figure being made.

A GIGANTIC EARTHWORM.

THE attention of scientists has recently been attracted by Mr. Baldwin Spencer, professor of zoology at the University of Melbourne, to an earthworm which inhabits Australia, and which attains the length of six feet. This, certainly, is an unusual size for creatures that in our country very rarely exceed eight inches in length. Yet the very recently discovered Australian worm is not the only one of its family that is of so gigantic a size.

Worms are in general humble creatures. They are of a relatively inferior organization, and are in most cases of small size. Let us not forget, however, that there are Nemertians, such as the Borlasie of the English, that attain a length of more than thirty feet. We know of gigantic Eunices, of the tropical seas, whose length is not far from six feet; and the colony of individuals called a Tænia sometimes exceeds twenty-five feet in length. The history of the Australian worm is given in English *Nature*. When I was reading the article of our London *confrere*, my memory reverted to some large lumbrics, a foot long, that I collected during the course of my travels in Malaisia and India.

I remember, too, some fragment of large earthworms that the Papuans brought to me at times when I was located at Havre de Dovey in New Guinea; but there is nothing that recalls to me this huge Australian worm as large as a medium-sized adder, and six feet in length.

I hastened to the museum to ask Prof. Perrier, whose remarkable works on worms and echinoderms are known to our readers, what he thought of this strange creature. The amiable scientist thereupon showed me various types of the museum's rich collection. There were here some lumbrics from New Caledonia two feet in length, and some Anteuses and Titanuses from South America reaching five feet. In the recently unpacked collections of the young traveler Guiral, who died at Gaboon a victim of his devotion to science, there is a worm several feet in length.

But the largest earthworm that we know of at present is the gigantic lumbric of Australia that Prof. MacCoy describes under the name of *Megascolides Australis*, and which inhabits the region called Gippsland. It seems that the *Megascolides* is not rare in that country. It prefers the banks bordering small rivers, but may be met with likewise in the open country on pulling up a stump or turning up the earth. As a general thing, this worm is found in the proximity of rivers, and it avails itself of the burrows of the decapod crustacea that dig into the earth there. The burrows of these crabs are long, round excavations that end in a chamber half full of water, and that receive air through an aperture extending to the surface of the earth and surrounded with a sort of crater of mud formed by the excavated material cast out by the crustacean. The *Megascolides*, like a practical worm, takes advantage of these burrows, and stealing into them, excavates galleries that intersect the primitive burrows, and thus moves about in the earth. When it wishes to come out, it makes its way up through the cone of mud; and so certain observers, witnesses of these facts and movements, thought it was the lumbric itself that made the excavations and formed the conical hillock which surmounts them and is over a foot in height.

According to Prof. Spencer, the surest indication of the presence of the worm beneath the surface is a very distinctly perceptible purling sound made by the animal on retiring into its hole when any one is walking in the vicinity. The professor asserts that after a person has once heard this sound, which resembles no other, he can no longer be mistaken as to it.

It is to be remarked that the cones of mud never exist at the entrance to the worm holes, but always at the entrance to those of the land crabs, and that in the places where the worms live alone these conical outthrows do not occur.

It appears that it is not an easy thing to pull the gigantic lumbric from its hole without breaking its soft and slimy body. The length of the worm and the sinuosities of the excavation render the operation troublesome and delicate. Let us take into account, too, the rapidity of the motions of this worm, which, once buried, seems to be an entirely different creature, and, like Antæus, to gain new strength on contact with the earth. Gliding and winding about in the sinuous galleries, whose sides are lubricated by the mucosities that the animal is constantly secreting, the *Megascolides* braces itself against the walls by inflating its posterior or anterior extremities at will. By these successive expansions and contractions, it pushes itself forward and moves around its galleries, while its moist body slips through the hands of those who wish to pull it outside. On passing through these viscid galleries, the body of the worm produces that peculiar sound spoken of by the observer, and the adhesion of the animal to the walls is such that it can be captured only by breaking it.

Along with this uncommon muscular strength, the *Megascolides* possesses physical features capable of defending it against such enemies as it might have. Its body exhales a strong odor analogous to that of creosote, and this odor continues to increase after the death of the animal, which then slowly resolves itself into an oily fluid that the aborigines consider as a sovereign specific against rheumatic affections. As if this disagreeable odor were not enough, the worm possesses the power also of projecting from its dorsal pores, and to a distance of several inches, jets of a milky liquid. This liquid serves to lubricate the walls of the galleries in which it moves about, and consequently to allow it to slide along with more ease therein.

But this creature, so agile underground, when once upon the surface of the earth seems to lose its locomotive faculties, and remains lying passive upon the ground, making no attempt to move. The habitations of the *Megascolides* measure, on an average, from ¾ in. to 1¼ in. in diameter.

What the role of these animals is in the economy of nature is something that future investigators will probably teach us. The great importance that for some years past has been attached in our country to the humble work of our earthworms is well known. Thus, by perforating the earth of our gardens in all directions with their galleries they render the soil more mellow; and they render it more fertile by accumulating in those galleries earth that has been elaborated in their intestines, and by collecting therein leaves that have fallen upon the ground and that they search for at night and drag into their retreats.

It is not for us to give the history of our earthworms in this place, for every one has known it ever since the appearance, in 1882, of Darwin's masterly work on the formation of vegetable mould by worms.

We shall conclude by stating that the cocoon in which our remarkable Australian lumbric incloses its

THE GIGANTIC EARTHWORM OF AUSTRALIA—(MEGASCOLIDES AUSTRALIS.)

embryo has been observed by Prof. Spencer. It is about two inches in diameter, is quite thin, hard and coriaceous, light yellow, then brown, and is elongated, and provided at each extremity with a tubular appendage.

In addition to the embryo, it contains a milky liquid analogous to that which the worm discharges through its pores.

These worms must have few or no enemies. Their large size, their repulsive odor, and their subterranean life suffice to shield them from the beak of the bird and the tooth of the carnivorous marsupial. The use of them in the materia medica of the old Australian natives cannot cause them to be very actively hunted for, and so these odd forms can multiply in peace.

It would be very interesting to know whether these gigantic worms, which it seems are abundant in some regions, could, in time, change the configuration of the ground. There is no doubt that former geological epochs have also possessed large worms. Have these worms, through their multiple perforations, been able to contribute, not only to the mellowing of the soil, but also to the creation of spongy sedimentary rocks? This is something that I shall not dare to assert. Bayer, Knorr, and Goldfuss have studied and figured some of

the fossil impressions of the Jurassic lumbrici. The mass that fills the interior of these moulds is, as well known, of spathic nature, and of a gray color often shaded with brown by oxide of iron. It is well to add that the fossil lumbrici are far from being well known. Agassiz considered these impressions as formed in part by cololiths, that is to say, by intestines of petrified fishes. Some prefer to regard them as the solidified excrements of annelids, and others, again, as intestinal masses voided by Holothurians.—*M. Maindron, in La Nature.*

SPONGES.

AT a recent meeting of the Physiological Society, Berlin, Prof. F. E. Schulze spoke on the organization and mode of living of sponges. The simplest form of sponge consists of a sac, which, being composed of three layers, is equivalent to the embryonic form of the more complicated types. This sac is attached by its base, and has at its apex an opening—the osculum; its wall is composed of an outer layer of epithelial cells (ectoderm), a middle layer of connective tissue with migratory cells (mesoderm), and an inner layer of collared flagellated cells (endoderm), and is perforated with round and regularly distributed apertures. The more complex forms arise by a thickening and folding of the wall, the thickening being still more marked in the most complicated forms. In these, a system of branched canals takes the place of the simple apertures in the wall, communicating with the exterior by round openings, and leading internally into cavities lined with collared flagellated cells (choanocytes); from these cavities a further system of branched canals leads into the now limited internal cavity with its osculum. The skeleton of the sponge is composed of chalk, siliceous earth, spongin, or foreign substances.

In the simplest sponges, consisting of a simple sac, the skeleton is made up of the simplest star-shaped spicules, with three rays, so as to give support to a membrane which is perforated with regularly alternating apertures; in the more complicated forms, these spicules possess four or six rays, as supplying the most convenient supporting structure, while a collar of simple rays is developed round the osculum. According to the material of which the skeleton is chiefly composed, sponges may be classified as chalky, siliceous, horny, or sandy. The Hexactinellidæ, with six-rayed spicules, inhabit deep seas.

In all sponges, a continuous stream of water is observed entering the openings on the surface of the body, and emerging at the osculum, so that the sponges filter the water in which they live. The movement of the water is brought about by the flagella; the contraction and retraction of the osculum is produced by elongated protoplasmic cells, but these cannot be regarded as muscle cells until it has been proved to a certainty that they are connected with nerves, and receive their impulse from these nerves. Only one observer has as yet described a nervous system in sponges, the majority not yet having seen it. Nothing has as yet been definitely ascertained as to the mode of nutrition of sponges; from among the several hypotheses, some suppose that the solid organic particles which are suspended in the water are taken up by the ectoderm cells and digested in the body; or else that these particles are taken up by the flagellated cells—that is to say, are passed from within outward; or that the digestion is cellular, inasmuch as the amœboid migratory cells take up the food particles, digest them, and pass on the digestive products to the rest of the body; or, finally, that sponges, like plants, only absorb food stuffs in solution. The reproduction of sponges is both asexual and sexual, the first resulting from natural or artificial fission; natural fission, consisting of a simple separation, by constriction, of a portion of the body substance, occurring in fresh water sponges. Another asexual mode of reproduction is by means of buds and gemmules. In the sexual mode of reproduction, the females develop eggs all over their surface, and the males spermatozoa, the latter consisting of a head and tail. The egg, after impregnation, goes through the various stages of segmentation met with in the higher animals, and then develops into a sac-like embryo.

A SIMPLE ASTRONOMICAL INSTRUMENT.

By HUGH D. VAIL.

THE drawing represents a simple, inexpensive instrument that can be used on land instead of a sextant to find the correct time by measuring the zenith distance of the sun.

It is easily made, being entirely of wood, except the fastening, two screw-eyes and two thin pieces of steel at H and B, each having one end screwed fast under the bottom and the other end free, so that it can be moved up and down by a screw-eye through the wood above it to level the instrument. A piece of an old saw blade will serve for each of these.

The drawing shows the construction. The bottom, uprights, and braces are boards (pine, cedar, or redwood, well seasoned and straight grained, so as not to warp), about 3½ inches wide. The bottom one may be about five feet long, and the others about in the proportion represented. But this is not material.

On each side of the bottom, to stiffen it, a thin strip three inches wide is fastened by screws. Between these, at L and O, two rectangular blocks, having their tops in the same plane, and used to lay the level on, are firmly screwed to the bottom.

At A, about a foot below the top of the taller upright, is an opening slanting downward from the outside, so that the sun can shine through it when at a considerable elevation, and covered on the inside with a piece of sheet zinc or tin pierced with a small pin hole. The sun shining through this minute hole, toward the opposite end, will form an image of itself, as at S.

If in this case the upright, A B, is vertical, it is evident that the angle, S A B, will be equal to the apparent zenith distance of the sun.

To complete the instrument and find this angle astronomically, a strip of white paper is pasted on the inside of the smaller upright and brace, and divided by a number of equidistant horizontal lines, whose distance apart should be about half the diameter of the sun's image, so that when its center is on any one line the edges will just touch the lines next above and below. The lines should be numbered.

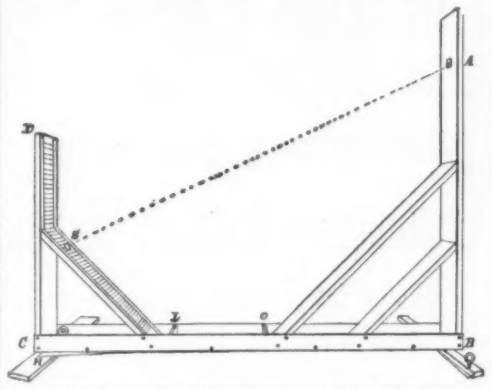
When this has been done, the instrument is placed on the floor near an open window, through which the sun is shining, in such a position that its image may fall on the scale. The two ends are supported on strips of wood a foot or more in length, as shown in the figure, to correct the inequalities of the floor. The one at B has a screw-eye and metal strip for leveling transversely. The one at C can be pushed over the floor to keep the image near the middle of the scale, while observing. The instrument having been leveled transversely by the screw-eye at B, and lengthwise by that at C, the times at which the center of the image is on several lines are carefully noted by a good watch. This observation should be made three or four hours before noon, and in the afternoon when it recrosses the same lines the times should be again noticed. The mean of the times when it crosses and recrosses the same line, or when the sun is of the same altitude in the morning and the afternoon, is very nearly the true time of noon. It would be exactly were it not for the sun's change in declination. The correction for this (only a few seconds) is readily calculated, and when applied gives the correct time of noon by the watch.

The difference between this and the true time of noon given in the almanac is the error of the watch.

The error of the watch being known, we know the true time of each observation, and having this and the latitude of the place, the corresponding zenith distance of the sun can be computed. In the same way it can be found for other lines, and a table of all the angles made, to be used for finding the time by a single observation in the morning or afternoon.

The angles found in this way being the true zenith distances of the sun's center, they require no corrections, such as have to be made for semi-diameter and refraction when a sextant is used, and, with a sensitive level, can be measured quite as accurately.

In order to have the image well defined on the scale, the part where it is formed should be well shaded by



A SIMPLE ASTRONOMICAL INSTRUMENT.

either covering a part of the window or by hanging a pasteboard or paper screen on the upright with a hole in it opposite A, or by both.

This instrument is in use at Santa Barbara, Cal., for regulating the town clock. Before the city had railroad communication it was found especially useful.

RICE CULTURE IN CENTRAL CHINA.

By B. J. FRANKLIN, U. S. Consul, Hankow.

RICE is largely cultivated in all the provinces of this consular district; it is the leading agricultural product of some of them, and the chief article of food of a large majority of the people of China. Its importance as an article of food can only be properly estimated when we consider that fully one-fourth of the human race chiefly subsist upon it.

Great care and unremitting labor is bestowed upon its cultivation throughout China from the time it is sown in beds, prior to transplanting, until it is harvested. A bountiful harvest is hailed with joy; it produces prosperity in all branches of business, while a short crop is the precursor of hard times, and entails much privation and suffering upon the laboring classes.

The mode of cultivation is the same in all portions of the empire, differing only in some minor details. The time of planting the crop varies according to the latitude. In some portions of the country north of the Yang-tsze, the beds or patches of ground in which the plants are grown are prepared for the seed as late as the middle of April, and the work of transplanting done as late as the middle of May. In the extreme southern provinces the crop is planted at a much earlier period. Two crops are raised each year in many of the provinces, though in this province (Hupeh), in the vicinity of Hankow, it is frequently the case that the farmer, after the crop of rice is harvested, does not plant the second crop, but plants the field in vegetables. Sometimes a crop of wheat or barley is first grown, followed by a crop of rice. The farmer does not at all times realize the most profit by this alternation of crops, but his land is not so much impoverished by this method, and his outlay for manure is necessarily less.

Rice, in this province, in the vicinity of Hankow, grows from three to five feet high, and when standing in the field, immediately preceding harvest, has somewhat the appearance of oats, though it usually has a less number of branches from the main stalk.

In addition to careful and thorough cultivation, the most powerful agents in producing a good rice crop are plenty of water and a liberal application of manure. The fields are flooded from the time of the first plowing till nearly harvest and manure bountifully applied. The soil, though very fertile, requires to be supplied with manure, I am of opinion, more on account of the inferior methods of tillage than anything else. The land is not broken sufficiently deep, and that is the primary reason why many really fertile fields require manure. But any attempt to convince a Chinese farmer that a modern plow would be the means of producing a more abundant harvest and cause a less expenditure in the application of manure, would be time thrown away. He prefers to follow in the old, well-beaten track that has been followed for centuries by his ancestors.

SIZE OF FARMS IN CHINA.

Land is held in small tracts, as a general rule, and the word farm in China has a far different signification from what it has in the United States. A farm often contains not more than 3 or 4 mao,* and sometimes less; but in some sections of this province (Hupeh) holdings of from 100 to 150 mao are not uncommon, and in rare instances larger tracts are owned.

The owners of the large tracts do not cultivate them, but lease them and receive rent in kind, usually about one-fifth of the crop when the tenants supply everything.

AGRICULTURAL IMPLEMENTS IN USE.

The agricultural implements used by the farmers of China are of the rudest construction, and of the same kind and pattern that were in use centuries before the Christian era. No modern farming machinery or utensils of any kind are used by the natives in any portion of the empire. One may travel hundreds of miles in the rural districts and never observe any change, no progress in any direction. The methods of tilling the soil in all respects are just the same as they were hundreds of years ago. Labor is abundant and very cheap, hence no thought is given to modern methods of agriculture. The farms are of such limited area and labor so easily procured at such astonishingly low rates that, in the estimation of the Chinese farmer, improved implements are not needed. He doubts the expediency of changing the old methods, when able-bodied, industrious farm hands can be obtained at from $8 to $12 per annum.

There is a great prejudice in this province against anything foreign, and it would be almost impossible to introduce any kind of modern labor-saving implements.

PREPARATION FOR SOWING THE SEED IN BEDS PRIOR TO TRANSPLANTING.

A small plat or patch of ground, of sufficient area to produce enough sprouts to plant the intended crop, is first well manured, and then thoroughly broken by the spade or plow, generally by the spade if the field to be planted is not too large, and, after being finely pulverized by a common hand rake, is ready for the seed. If the crop is to be a large one, requiring a field of from 25 to 100 mao, the bed is made ready for the seed by harrowing. The paddy (unhusked rice) is then sown broadcast, and the ground flooded with water to the depth of from two to four inches.

The transplanting beds in the vicinity of Hankow are prepared from the middle of March to the 1st of April, and the crop is planted at any time from the 15th of April to the middle or last of May. In very early seasons the preparation of the beds and the planting of the crop occurs somewhat earlier. Before the seed is sown it is placed in water and soaked until it commences to sprout, which occurs in three or four days. The plants or stalks are ready for transplanting in about thirty days from the time of sowing, and are then from five to eight inches high.

MODE OF CULTURE.

The ground is broken twice by a common Chinese plow, of very rude construction and primitive pattern, drawn by a water buffalo or common Chinese ox, guided by a ring in his nose, attached to a hempen or bamboo rope. The yoke is generally made of bamboo, sometimes hemp, and the shafts or traces are of the same material. The plow is a clumsy-looking affair, made of wood, and shod with iron at the point. It is the mere apology for a plow, and turns up the soil only to the depth of four or five inches. An American farmhand would not use one, and a well-to-do planter would not allow one to remain on his plantation.

Where the field to be tilled is of small dimensions, it is usually broken by the spade, hoe, or mattock. Sometimes it is the case that two or three generations of the same family own and cultivate the same tract of land. It has probably descended to them through many generations. In such cases, unless the holding is large, no outside labor is employed. None is necessary, for every member of the family, both young and old, can be profitably employed at certain seasons in the culture of rice. After the first plowing the field is inundated with water and then broken again, after which it is harrowed two or three times, or until the soil is thoroughly pulverized. The harrow is equally as rudely constructed as the plow. A very common kind is made of a heavy piece of wood from 8 to 12 inches square and from 4 to 6 feet long, and to which is attached an upright framework by which the driver guides it, and by pressing upon the upper cross piece causes it to sink to sufficient depth. In this kind there is but a single row of strong wooden teeth. Those of both triangular and square shapes are in frequent use. The pattern varies according to the ingenuity of the farmer, for, as a general rule, they are home-made.

When the ground is properly prepared, and the shoots or sprouts are of sufficient growth, the transplanting of the crop begins. The plants are carefully drawn from the bed, placed in baskets and conveyed to the field. They are planted three or four shoots in the same place, and about six inches apart, and in rows from eight to fifteen inches apart. Those who do the transplanting do not leave the field, but are supplied by others who bring them the plants fresh from the bed. Two men can transplant about five mao a day. Tea is served several times during the day to the laborers in the field.

The Chinese farmer places a high value upon fertilizers, and the ground is liberally supplied with manure before it is broken, and liquid manure is frequently applied near the roots during the growing of the crop. Where the water supply is abundant the fields are flooded several times during the season, and the growing rice is kept well watered until nearly harvest time. China abounds in rivers and small streams, and has a network of numberless canals from which the rice fields adjacent are irrigated. Where fields are remote

* Land is measured by the mao, and in this province 6 mao are about equivalent to 1 English acre. The word mao has the same meaning and signification as the English word acre, in its primitive sense, and the German word acker, and is used to designate a field or measure of land. The mao is larger in some provinces than in others, just as the acre varies in area in the United Kingdom. The following is the land measurement in China: 4 chio = 1 mao; 1 mao = 16·73 square rods; 100 mao = 1 ching; 1 ching = 16·7 acres.

from a natural water supply, wells are dug and reservoirs constructed, from which the water is drawn by buckets attached to the old fashioned well sweep. From the time of transplanting until nearly harvest the laborers are in the field stirring the soil and removing the weeds. The work is not only laborious, but is always unpleasant on account of the odor that arises from a mixture of manure, soil, and water. It requires about two and one-half bushels of grain to sow an English acre, and the yield in this province is from eight to twelve fold, according to the fertility of the soil.

In about ninety days after transplanting the rice is ready for harvesting. It is cut with a sickle, bound into sheaves, and stacked. The sheaves or bundles are carried to the stack by coolies and stacked in a manner similar to the way in which grain is stacked in the United States when no machinery is used. Sometimes a large farmer owns a small rough cart in which he hauls the sheaves to the stacking ground. The cart is constructed of rough wood. It has shafts and solid wooden wheels, and when heavily laden is drawn by two or three bullocks driven tandem.

THRESHING AND CLEANING.

No improvement has taken place for centuries in the methods used for threshing and cleaning grain. Threshing is done either by hand with a flail, or the rice in the straw is placed on a threshing floor and oxen driven over it.

It is then winnowed by pouring it from uplifted baskets when the wind is sufficiently strong to separate the paddy from the chaff, or by a fanning machine, similar in construction to the wheat fan used in the United States before the introduction of improved machinery for cleaning grain.

The straw is used for making sacks and bags, thatching roofs, making rain coats for farm laborers, and as food for cattle.

The chaff and husks are used in packing crockery ware, and for various other purposes. When mixed with bran, it makes good food for cattle.

After being threshed and separated from the chaff, it is ready for the husking mill. There are several methods for taking off the husk or outer siliceous coating. In this vicinity it is generally done by hand, by placing the paddy in a wooden or stone mortar and beating it with a wooden pestle. Two hands by this mode can husk about three piculs per day.

Water is used as the motive power in many parts of the province, but I have never seen a watermill either for grinding grain or husking rice in this vicinity. Laborers are numerous; they can be hired for very low wages, and machinery for expediting labor is but slightly esteemed. The work performed by horses and mules in the United States is performed by coolies in China.

The farmers sell the surplus of their crops to the local rice dealers, and all that is not required for the local market is sent to the large cities.

All the rice raised in this province is required for home consumption; and when there is a short crop the supply falls far short of the demand, in which case it is imported from other provinces. Although this province contains a population of about 35,000,000, the rice supply would doubtless be sufficient were it not that immense tracts of fertile land bordering on the Yang-tsze river can not be devoted to rice culture on account of being annually overflowed. The floods usually come before the rice fields are ready for the sickle. All such lands are utilized in raising crops that ripen early.

It is impossible to give exact statistics of the production or consumption of rice in this consular district, as no reliable record is kept.

I am informed that it is usual to import from other provinces about one-fifth of the quantity needed for Hupeh.

Formerly tribute rice was sent to Peking from this province, about 90,000 piculs being exacted every year; but for many years money has been forwarded in lieu of rice. The custom is of ancient origin, and it is for the use of the imperial household, for the soldiers, and for distribution in years of famine.

PROBABLE YIELD FOR UNIT OF LAND IN AN AVERAGE YEAR.

Good land, when the season is favorable and the crop well cultivated, will yield about 5 piculs, *i. e.*, in two crops, per mao each year, which, when husked, amounts to about 3 piculs of clean rice. Farmers near Hankow estimate the area of their rice fields by teu, or peck, of ground, probably because it takes about a peck of seed to sow that much ground.

It requires 10 shing to make 1 teu, and 10 teu to make 1 tan. Shing is a Chinese measure about equal to 1 English pint. It formerly was made to hold one catty, and is a very common retail measure in China. I have not been able to ascertain the exact superficial area of a teu, but am of opinion that it contains about the same quantity of land as a mao. Farmers claim that what they call a teu will produce in two crops about 5 piculs of unhusked rice, and that is the estimate placed upon the product of a mao.

THE AVERAGE CONSUMPTION IN A FAMILY.

Among the poor, who eat but little besides rice, the amount daily consumed may reasonably be placed, all round, at about 1 shing, or English pint, of unhusked rice to each person. A child would eat less, an adult would eat more, while a man with a good appetite, who labors hard all day, might eat 2 shings per day. Vegetables and either pork or fish are generally eaten with rice, and then the quantity consumed is much less.

An industrious, able-bodied Chinese laborer is by no means poorly fed. He gets an abundance of rice and a liberal allowance of fish, vegetables, and pork. Especially may this be said of the coolies of Hankow.

Rice properly cooked is both a nutritious and delicious dish. When prepared by an experienced Chinese cook it is placed before you, not a pulpy mass, robbed of its nutritious and palatable qualities by being boiled in a deluge of water, but each grain is separate, distinct, and white as the fresh-fallen snow.

AVERAGE PRICE OF RICE.

The price of rice varies considerably from year to year, 2,000 cash being a low price at Hankow for 1 picul of inferior rice. In the country it can be bought at a low rate. The price is lowest just after harvest, and rises from that time until the next crop is gathered. As a general rule, it appears to rate each year from 2,000 to 2,600 cash per picul for an inferior grade, and from 3,000 to 3,600 cash for the best quality of rice. A Mexican dollar is equivalent now to 1,080 cash, and the Mexican dollar, according to the estimate placed upon it January 1, 1888, by the Secretary of the Treasury, is worth 75·9 cents in gold. It will thus be observed that a family of six persons, subsisting almost exclusively upon rice, can live at a cost of about 20 cents (Mexican) per day. When vegetables and fish are added the cost is not increased, for a correspondingly less amount of rice is consumed. Almost every farmer, be his holding large or small, has a little patch of ground devoted to the cultivation of vegetables for family use.

COST OF CULTIVATION.

Two laborers can cultivate 20 mao (about 3½ acres) per year, the average yield of which would be about 100 piculs of paddy or 60 piculs of clear rice. The price of good field hands, when furnished with food and lodging, ranges from 12,000 to 15,000 cash (equivalent to $7.50 to $10.50 in gold) per year. Day laborers receive from 60 to 80 cash and food per day.

Rice is annually imported, and formerly, when vessels were laden with it alone, no tonnage dues were charged. Its exportation is prohibited by law. Rule 3 of the Chinese customs tariff, *inter alia*, says: "The export of rice and all other grain whatsoever, native or foreign, no matter where grown or whence imported, to any foreign port is prohibited."

It is an important factor, however, in the internal commerce of the empire. Immense quantities of it are shipped to this city from all portions of Hupeh and adjoining provinces.

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN
Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. AGRICULTURE.—Rice Culture in Central China.—By R. J. FRANKLIN.—A very full account of Chinese husbandry, the methods, implements, and fertilizers employed, with statistics of production per given area..... 11205

II. ASTRONOMY.—A Simple Astronomical Instrument.—A very easily constructed instrument for taking equal altitudes to determine the true time..... 11205

III. BIOGRAPHY.—Jacobi, the Inventor of Electrotyping.—Biography of the inventor of the art of electrotyping matter, with portrait.—1 illustration..... 11200

IV. BIOLOGY.—A Gigantic Earthworm.—An earthworm six feet in length, a native of Australia, its habits and methods of defense.—1 illustration..... 11204

Sponges.—Notes on the organization and life habits of sponges.. 11205

The Habits of Thalessa and Tremex.—By C. V. RILEY.—The continuation of Professor Riley's interesting paper on these insects, with numerous examples of their habits.—3 illustrations.... 11202

V. CIVIL ENGINEERING.—Plant and Material of the Panama Canal.—The study of apparatus, especially of the excavators of different types as used on the canal, continued; how the plant was installed, with railroad and other connections.—6 illustrations.... 11195

VI. ELECTRICITY.—Note on the Use of Geissler's Tubes for detecting Electrical Oscillations.—A very ingenious application of Geissler's tubes to the study of the famous Hertz electrical oscillations or waves..... 11200

The Tele-indicator.—An apparatus for use in indicating at a distance the movements of meteorological and similar appliances.—1 illustration..... 11199

The Type-Printing Telegraph.—A single-wire apparatus that produces telegraphically a regularly type-written communication.—4 illustrations..... 11198

VII. MECHANICAL ENGINEERING.—Nails from Tin Scraps.—A most ingenious effort to utilize this waste material.—A graphic description of the elements of the problem and its solution.—2 illustrations..... 11198

VIII. MEDICINE.—Sulphonal.—The new hypnotic.—Its value as a therapeutic agent, with details of its effects on the system..... 11201

IX. MISCELLANEOUS.—The Paris Exposition—the Central Entrance and Dome.—The great portal and dome, with particulars of its wonderfully quick erection.—1 illustration..... 11191

The Paris Exposition—the Illuminated Fountains.—An interesting study in reflection of light and the application of optical science to the beautiful electrically illuminated fountains of the exposition.—6 illustrations..... 11192

X. NAVAL ENGINEERING.—Armor for Ships.—A valuable paper recently read before the English Institute of Civil Engineers.—By Sir NATHANIEL BARNABY, K.C.B.—Interesting comparisons of ships of different epochs.—1 illustration..... 11196

Wate-Tube Boilers for War Ships.—By J. I. THORNYCROFT.—Study of quick-steaming boilers from the standpoint of the naval engineer.—Examples in practice and their lessons.—5 illustrations 11194

XI. PHOTOGRAPHY.—The Stripping of Fibers from Gelatine Negatives for Photo-mechanical Processes.—Full formulæ, with details of manipulation for executing this important operation..... 11192

XII. PHYSICS.—On Flame.—By F. J. ROWAN.—A paper embracing the physics and chemistry of flame, with extensive references to published researches.—A valuable contribution to this subject.... 11201

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.

889.

ent.

in any
llars a

rom the
Price,

an like-
yearly,
er $3.50

AMERI-
UPPLE-

nts, and

N. Y.

PAGE
. J.
the
s of
... 11205
very
de-
..... 11205
gra-
por-
..... 11200
et in
se.—
..... 11204
zes.. 11205
The
e in-
.... 11202
ama
s of
was
.... 11195
ect-
iss-
ions
..... 11200
dis-
es.—
..... 11199
that
ica-
..... 11198
—A
de-
lus-
..... 11198
s a
..... 11201
En-
g of
..... 11191
ter-
ical
the
..... 11192
aper
-By
s of
... 11196
T.—
aval
ons 11194
ega-
ails
..... 11192
cing
s to
..... 11201

oks

ineers,
ssional
f their
ermits
t very
books
t sub-
lation,
with
e only
ress,
York.

rican,
n and
e, and
world.

meri-
gency.
By the
ion is
les or

inven-
patent
& Co.
Patent
s and

ork.